THE PLACE OF CLIMATOLOGY IN MEDICINE

THE HYDE LECTURES, 1913

WILLIAM GORDON

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BEING THE

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BY

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With the Writer's kind regards.

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PREFACE

These Lectures claim to show, *inter alia* :—

1. The great importance of climatology in medicine and the seriousness of its present neglect.

2. The need for the recognition of a new principle in climatological investigation, viz. the principle of approximate isolation of influences.

3. The absence of any valid evidence that altitude *per se* affects the prevalence of phthisis.

LECTURE I

Sir Hermann Weber and Gentlemen,—I have first—and the duty is a pleasant one—to offer to the council and members of the section my best thanks for the honour they have done me in asking me to deliver these, the second, Hyde Memorial Lectures, and for the added honour, Sir, that you preside. When their kind invitation came, I felt a good deal of misgiving as to whether I ought to accept it; it seemed no light matter to me, whose province is general medicine, to address men in their own special department of knowledge, who are so well fitted to instruct myself. But, as I thought over the possible reasons why I had been asked, one seemed to suggest itself which encouraged me to make the attempt. The opening lectures of a long series, such as we must suppose that these will be, are not unlike the introduction to a bulky volume, and may be expected to survey the whole subject from a general point of view. Such an introduction I thought a general physician might write; such an attempt, at all events, I now venture to place before you. My predecessor, Dr. Fortescue Fox, in his interesting lectures last year, dealt in the broad fashion I refer to with the subject of hydrology, the *περὶ ὑδάτων* of Hippocrates. To me this year have fallen the *περὶ ἀέρων καὶ τόπων*. I propose to consider their place in contemporary medical study, to indicate their immense real importance, and, whilst noting their general present-day neglect, to suggest certain remedies which may tend to restore them to the place that is rightfully theirs. How far my performance in this programme is going to fall short of my opportunity I am only too painfully aware. But, as Browning puts it, "let your better wit mend all."

My second duty—and privilege—is to call to your recollection him in whose honour these lectures have been named. Dr. Samuel Hyde was born at Stalybridge in Cheshire in 1849, and received his medical education at King's College, London. He settled at Buxton in 1877 as medical officer of the "Peak Hydropathic and Thermal Establishment," and afterwards in private practice, acquiring the reputation of a skilful, observant physician, thoughtful and thorough, deeply imbued with the faith of fruitful experience in the efficacy of waters and climate in the treatment of disease. Literature on the subject was then limited, and his editings and writings added valuably to what was available. In 1889 he inaugurated a Journal of British and Foreign Health Resorts, and in 1895 he and Dr. Septimus Sunderland founded the British Balneological and Climatological Society, the parent of this section, thus providing for the first time a common meeting-ground for the medical observers at the various British health resorts, a notable service to the medicine of this country, and one we do well to specially commemorate. Hyde also became the editor of the Quarterly Journal of the Society. Dr. Fox, who knew him well, has described him as an indefatigable worker, patient and persistent, with the imagination to conceive and foresee, the constructive ability, courage, and perseverance to achieve, a personality of rare effectiveness and charm. When death claimed him at the early age of fifty his work was already complete—a British school of balneology and climatology had been created.

THE IMPORTANCE OF MEDICAL CLIMATOLOGY

To realise the importance of medical climatology it is only necessary to define it. Yet this is not so simple as might at first sight appear; definitions are generally difficult, and this one seems to have been found exceptionally so. Modern authorities have commonly dealt with climates merely in terms of average local weather. But in its medical aspects, at all events, climatology covers more than can be so expressed. When we talk of a climate being good or bad in a medical sense, it is not only weather which we have in mind. Doubtless something may be said for the view that

the effects of climate are ultimately results of meteorological conditions, at least where neither the inhabitants nor their habitations go barefoot on the soil, and if we exclude hydrology. But many of these meteorological conditions cannot at present be determined; of the existence of some of them we are probably unaware; so that we are obliged, for practical purposes, to include in our definition, as in our investigations, topographical factors whose meteorological consequences still remain to be unravelled. In making this compromise it is curious to observe that we are but following the lead of the "Father of Medicine," who summed up his subjects as "airs, waters, and places."

I would therefore define "climate" and "climatology" in their medical aspects thus: "The climate of a place, in a medical sense, is the sum of the influences upon human health and sickness of its geographical, and especially of its meteorological conditions"; and "Medical climatology is the science of climates medically considered and of their variations in space and time." So defined, it is clear that climatology constitutes a great part of the environment of medicine, and that to neglect it is to ignore most of the natural history of disease.

Medical climatology may be divided into "descriptive" and "theoretical"; "descriptive," embracing "medical geography," which treats of the distribution of disease over the earth, and "medical history" concerned with records of epidemics and those changes in prevalence or type which diseases undergo; "theoretical," including what may be termed "geographical" and "historical pathology," sciences which should set forth the laws which govern these distributions and periodicities.

THE PLACE OF CLIMATOLOGY IN THE PAST

No survey of my subject could be considered complete which did not take cognizance of the past. Nor will a brief retrospect be devoid of practical advantage.

In the dawn of European thought, during the epoch in which the Greek genius attained its zenith, that is to say, in the sixth and fifth centuries before Christ, men apparently looked on life more directly and comprehensively than we

do now; and sometimes reached, as it were intuitively, simpler and saner views. Thus it has been held by no mean modern thinkers that, in the great writings of twenty-four centuries ago, guidance is still to be gained in those confused problems which our murkier mental atmosphere presents to us. So it seems to be in medicine. For the work of Hippocrates on Climatology, brief as it is, translatable in less than 9,000 words, takes a view of the subject whose width is only beginning to be understood. In that work seasons and soils, winds and waters, aspects, shelters, and exposures, altitudes, temperatures, vegetation, the habits, food, and drink of the inhabitants, are all taken into account, and not merely as affecting disease but normal development, not only the physical characters of races, but their moral characteristics—even the excellence of their art and their success in war. "Whoever," says the Master, "wishes to investigate medicine properly," must attend to these things.

It would be rash to conclude that so wide a presentment of the subject was entirely original in the time of the writer, and, in fact, we have indications that his predecessors and contemporaries were accustomed to lay stress on such considerations. Whether this arose from the peculiarities of their training in natural health resorts, or from the marked differences which obviously existed between climates familiar to them, we do not know. But the story that Empedocles of Agrigentum improved the climate of his native town in Sicily by blocking up an opening betwixt two hills shows that the ancients realised how much depended on knowledge of this sort.

This primitive width of outlook was not, however, maintained. So far as I can discover, subsequent writers gave the subject narrower treatment: even Aretæus, regarded as the second most distinguished of the physicians of antiquity, dismissed climatology almost in a page. Perhaps the great anatomical researches of Alexandria had turned men's minds into different channels. Celsus and Galen apparently had little of importance to say on the matter. The great Arabic commentators, whether at Baghdad or Cordova, appear almost to have passed it by. Even the Renaissance gave it slight attention. Sydenham in England was exceptional in the stress he laid on the seasonal varieties of disease, follow-

ing in this his favourite model, Hippocrates. But even Sydenham, so far as I can see, made no valuable advance; and, until the great medical era of the nineteenth century, the place of medical climatology was far more limited than it had been in primitive times. Then, however, a wider activity set in. The extension of facilities for travel was succeeded by the growth of medical geography; medical history followed in natural sequence; and a study of their theory began. Further than this, historians like Buckle and Draper, philosophers like Herbert Spencer, took up the thread of speculation on the influence of climates upon races, where Hippocrates had let it fall; so that once more, after so many centuries of comparative neglect, the whole fabric of ancient thought upon the subject rose into view.

THE PLACE OF CLIMATOLOGY IN THE PRESENT

And this brings us to a survey of the extent of our present knowledge.

At the outset one must distinguish the factors which enter into climatology, so far as they have hitherto revealed themselves. Sixteen may perhaps be enumerated, half of them *meteorological*, half *topographical*. These are set forth in

TABLE I

Climatological Factors

Meteorological	Topographical
Temperature.	Latitude.
Wind.	Geographical position—by which is meant relation to land and sea, lakes, mountains, etc.
Rainfall.	Altitude.
Sunlight.	Soil.
Electricity.	Vegetation.
Atmospheric pressure.	Water-supply.
Atmospheric humidity.	Wind-shelter and exposure.
Atmospheric purity.	Aspect.

Other Factors sometimes requiring Elimination

Race.	Sanitation.
Closeness of intermarriage.	Preventive measures against disease.
Sex.	Prevalence of other diseases connected in any way with the disease in question.
Age.	Progressive change in prevalence with the lapse of time.
Occupation.	
Density of population.	
Poverty.	

Table I. All of them have been considered in one way or another in relation to disease, and already our gains are great, though modest indeed compared to what they may be. But for satisfactory knowledge of their action we require not only to be acquainted with their relations to human disease, but also to know their influence on human beings in health, as well as on the parasites which produce human disease, and on such non-human hosts as harbour them.

Needless to say it is not my purpose to weary you with a systematic outline of knowledge so familiar to you. I shall only recall what is necessary to illustrate my point, the immense importance of the subject; and if I dwell on this fact or on that at greater length, it is only because it bears on an illustration which I shall presently give of what I conceive to be a fundamental principle.

Influences on Healthy Human Beings

Considering first their influences upon healthy human beings, the most powerful of all climatic factors seems to be *temperature*. Taken in conjunction with atmospheric humidity, it was suggested by the late Dr. W. R. Huggard, of Davos, as the most practical means of classifying climates, and, although it may be questioned whether the time is yet ripe for any sort of classification to be satisfactorily laid down, whatever grouping may be ultimately adopted, temperature will almost certainly have to be one main means of climatic division. Ranke has made the pregnant observation that there seems to be an optimum temperature for human beings, which, he says, necessitates the least amount of metabolism compatible with healthy active life. He has placed this optimum between 59° and 68° F., within, in fact, about the limits of temperature which experience has shown us to be best for a pneumonia patient. In hot climates, where least metabolism is required, less food is consumed and there is a disinclination to exertion. The abdominal organs are hyperæmic, the skin acts more and the kidneys less than in temperate regions, and danger attends conditions which involve considerable heat production, such as fevers, physical exertion, and excess in eating. In cold climates, on the other hand, more food is requisite to maintain

a healthy activity, but active exercise is commonly taken, and the skin acts less, the kidneys more.

Atmospheric humidity claims special attention from its important relations to temperature. The humidity reduces the tropical heat, but increases its oppressiveness, and people in hot damp climates become lethargic and relaxed. The effects of cold are also greatly modified by humidity; whereas in dry cold the removal of heat from the body is determined by the bodily needs, in damp cold there is a leakage of warmth which is difficult to wholly prevent. Clothes do not entirely control it, and wind, if it exists, considerably increases it. Humidity also acts importantly in lessening the intensity of light.

Atmospheric pressure has received a great deal of attention, chiefly because so many of those who have interested themselves in the effects of altitude have assumed that its influence is chiefly due to this factor. If, however, we set aside special effects, such as mountain sickness (the outcome of a diminished intake of oxygen) and an enlargement of the thorax of a compensatory sort, the most interesting indisputable result of diminished atmospheric pressure seems to be compensatory increase of the colouring matter of both plants and animals—in plants of the chlorophyll, in animals of the hæmoglobin and red corpuscles.

Winds have received strangely little attention. In damp cold the leakage of heat from the body becomes much greater in wind. Then certain winds are remarkably enervating, like the Föhn. East wind in Europe is detrimental to many persons, although we have no satisfactory knowledge of why this is so. East winds in these countries seem to have less ozone in them than south-westers, but what effect this difference produces we do not know.

Light increases colour and well-being, yet its precise action on human beings has received, I think, very little attention. Of *electricity* in its natural conditions we know practically nothing as a climatic factor. Yet recent experiments, in which it has been artificially used to stimulate plant and animal growth, suggest that electrical conditions may have powerful effects on climate. Of the influences on healthy men of *rainfall*, *soil*, *vegetation*, *wind shelter*, and *wind exposure*, we know practically nothing.

Thus, so far as what may be called "physiological climatology" is concerned, we know enough to indicate the importance of knowing more; yet we are still only on the threshold of the subject.

Influence on Parasites and their Non-human Hosts

We have learnt for certain that the effect of climate on some of the parasites of man and on their non-human hosts is profound. The study of tropical diseases has made this plain. Certain disorders are confined to certain zones of *temperature*. Thus, whatever may be found to be the organism of yellow fever, we know that it does not flourish in temperate climates. The mosquito that carries it and the mosquito host of malaria become rare also at certain altitudes where the heat is less. Other diseases are modified. Thus, phthisis in the tropics, whilst usually uncommon outside the towns, runs a more rapid course than in cooler latitudes. The gravity of type is probably due in part to the temperature, the rarity is perhaps a consequence of the intensity of light. We know there are optimum temperatures for organisms, as Ranke says there are for man. *Light*, again, has a profound destructive influence upon micro-organisms, especially direct sunlight. Apparently it is the blue, violet, and ultra-violet rays to which it owes this most important power. The comparative rarity of phthisis in the tropics just referred to, and in some high altitudes as well, may owe not a little to the disinfectant power of light.

Rain is popularly supposed to wash the atmosphere, and, whilst it is raining, it doubtless does so. But it is sometimes forgotten that heavy rain after drought causes unusually active development of organisms in the soil, and that these, when the air dries again, enter it as dust. Long-lasting drought decreases the number and the vitality of organisms in the soil. Of the *action of wind*, *air pressure*, *natural electricity*, and *soil* on pathogenic microbes we are, I believe, without information. Here, again, therefore, we have much to learn, and comparatively little has as yet been established.

Influence on Human Disease

Dealing next with the influence of the factors of climate on human diseases, we enter on a field where remarkable progress has been made. Medical geography has become an imposing branch of knowledge. A great empiric acquaintance with the effect of places on disease is steadily growing up. Of this I need say no more. Similarly, medical history is becoming constantly more considerable and precise. But when we come to the theoretical side of medical climatology we find ourselves considerably worse off. It is not too much to say that the most striking characteristic of our knowledge in this department is its uncertainty.

Phthisis is the complaint upon which by far the most has been written in reference to its relations with climate, both in respect of frequency and course. *Altitude* is an ancient subject of discussion. In Peru its influence has been extolled for time out of mind. In my second lecture I shall deal very fully with the claims of the "altitude theory of immunity," and propose to show, in spite of the labour expended on the subject, that nothing has hitherto been proved. *Latitude*, strange to say, has attracted less attention, though its effects are more certainly important. *Soil* has been repeatedly investigated, and, to those who have not read the original monographs of Bowditch and Buchanan, the relation of phthisis to dampness of soil is no longer open to doubt. To those, however, who have carefully sifted the evidence the question is still undecided. *Wind shelter and exposure* have engaged my own attention closely for the past fourteen years, but although the results of my work have left no doubt on my own mind, I cannot flatter myself that my convictions are shared by every one. *Atmospheric pressure* is, with some authors, a synonym for altitude. Yet there are strong reasons for questioning its effect. *Temperature* is probably a notable factor in determining the influence of both altitude and latitude, and its variations may have something to do with the effects of wind. Yet nothing is definitely ascertained. About *rainfall*, *atmospheric humidity*, *atmospheric purity*, *sunlight*, *local aspect*, *geographical position*, *vegetation*, *water-supply*, *and electricity* in relation to phthisis we know nothing positively, although with regard

to several of these a good deal is sometimes written which can only be looked on as surmise. In fact, considering the amount of labour hitherto spent on the theoretical climatology of phthisis, the real outcome has been extremely small. A terrible vagueness lies like a blight over the field of labour.

Other Tuberculous Diseases.—Other tuberculous diseases have scarcely been investigated climatologically, except where they have been included in the same figures with phthisis. It is interesting and very curious to observe that the *actual sea-front*, so hurtful in cases of pulmonary tuberculosis (as Walshe, I think, first pointed out, and as Ransome has urged), is highly beneficial in certain localities to so-called surgical tuberculosis. Of this no explanation exists.

Pneumonia.—The frequency and severity of pneumonia at high altitudes have been as much insisted on as the rarity of phthisis. It seems, in fact, to be well established that in many mountainous regions pneumonia becomes commoner and more deadly as altitude increases. Whether this depends on increased exposure to certain winds is a question awaiting investigation. Some very small figures, which I am going to submit to you, suggest that this may be the case. The idea that exposure to cold dry winds is an important cause of the disease is not new, and interesting instances of coincident prevalence of such winds and pneumonia have been given. The curious converse distribution of phthisis and pneumonia to which I have drawn attention might be due to differing wind exposures. For if phthisis mortality is increased in a given area by south-west winds, and pneumonia mortality by north-east winds, such a converse distribution might be expected. In the United States, according to the census of 1880, the generally converse distribution was most curiously marked. The following example of converse distribution may not be uninteresting to you. I have dealt elsewhere rather elaborately with the rural district of Okehampton, in Devonshire, where I mapped out the distribution of phthisis in the parishes, and the exposure and shelter of the parishes to different winds. The maps of phthisis distribution for the decade of 1890–1899 were found to present a most striking correspondence with the maps of exposure and shelter in respect of west and south-west winds. I here present to

TABLE II

N.E. Wind and Lobar Pneumonia

ALL DEATHS AT AGES 5 TO 70, OKEHAMPTON RURAL DISTRICT, 1890–1899

Name of parish.	Population 1891.	Deaths.	Annual death-rate per 1,000.
I. SHELTERED PARISHES:			
Iddesleigh	377	3	
Hatherleigh	1,437	6	
Monkokehampton	191	—	
North Tawton	1,737	4	
Bridestowe	586	3	
Bratton Clovelly	487	2	
Germansweek	211	—	
Honeychurch	35	—	
Totals	5,061	18	Average, 0·35
II. EXPOSED PARISHES:			
South Tawton	1,264	11	
Spreyton	388	4	
Chagford	1,460	7	
Gidleigh	129	—	
Belstone	181	2	
Okehampton (rural)	520	1	
Ashbury	69	—	
Inwardleigh	519	2	
Beaworthy	268	2	
North Lew	714	1	
Highampton	284	2	
Totals	5,796	32	Average, 0·55
III. IMPERFECTLY SHELTERED PARISHES:			
Meeth	203	1	
Broadwood Kelly	261	—	
Jacobstowe	222	—	
Exbourne	355	2	
Sampford Courtenay	866	9	
Drewsteignton	751	4	
Throwleigh	281	1	
Sourton	448	1	
Bondleigh	141	—	
Totals	3,528	18	Average, 0·51

you two tables showing the relation of pneumonia mortality to the exposure to north-east wind. The first, Table II., deals with all deaths between the ages of 5 and 70 during the years 1890 to 1899, the same as were investigated in respect of phthisis. Cases under 5 and over 70 were excluded as specially likely to introduce error from inclusion of broncho-pneumonia and hypostatic pneumonia. The assessment of shelter and exposure was that originally made for the phthisis investigation, and confirmed by my friend, Dr. E. H. Young, medical officer of health of Okehampton, who also kindly supplied me with the present returns. It is seen that whereas, in parishes sheltered from north-east wind only 0·35 per 1,000 died from lobar pneumonia, in the parishes exposed to the north-east 0·55 per 1,000 died, and in the parishes partly so exposed 0·51 per 1,000. In the case of pneumonia, however, even more than in that of phthisis, it is desirable to consider separately the female death-rates, because the women are presumably generally near their own homes, whilst the men may be at work in other parishes, and because the women's occupations are more uniform than the men's. Accordingly, Table III. has been drawn up dealing exclusively with female deaths at the same ages, and in this the contrast becomes much more striking. Whereas in parishes sheltered from the north-east only 0·26 per 1,000 died, in the parishes fully exposed to the north 0·61 per 1,000 died, and in the parishes partly exposed 0·34 per 1,000. It must, however, be remembered that this result is from a single and rather sparsely populated sanitary area, and that the figures dealt with are very small. It is worth presenting to you only as a suggestion of the desirability of further inquiry, and as an interesting corroboration of previous observations made by other methods. This relation of wind and pneumonia is one of which nowadays we hear very little. Yet it surely is one of some practical importance. The winds which appear to have the power of causing the disease seem almost everywhere to be cold and dry. *Temperature*, in fact, seems to enter largely into the causation of pneumonia, low temperature and wide variations appearing to promote the occurrence of the disease.

Bronchitis is often considered to be affected by the same influences as pneumonia. But this apparently is not altogether correct. The distribution of bronchitis, in the United

TABLE III

N.E. Wind and Lobar Pneumonia

FEMALE DEATHS AT AGES 5 TO 70, OKEHAMPTON RURAL DISTRICT, 1890–1899

Name of parish.	Female population 1891.	Female deaths 1890–1899.	Female death-rate per 1,000 per annum.
I. SHELTERED PARISHES:			
Iddesleigh	197	1	
Hatherleigh	724	4	
Monkokehampton	83	—	
North Tawton	927	—	
Bridestowe	309	2	
Bratton Clovelly	255	—	
Germansweek	102	—	
Honeychurch	17	—	
Totals	2,614	7	Average, 0·26
II. EXPOSED PARISHES:			
South Tawton	633	7	
Spreyton	193	3	
Chagford	728	2	
Gidleigh	57	—	
Belstone	89	2	
Okehampton	300	—	
Ashbury	37	—	
Inwardleigh	258	—	
Beaworthy	122	2	
North Lew	364	1	
Highampton	135	1	
Totals	2,916	18	Average, 0·61
III. IMPERFECTLY SHELTERED PARISHES:			
Meeth	91	—	
Broadwood Kelly	132	—	
Jacobstowe	113	—	
Exbourne	167	1	
Sampford Courtenay	429	2	
Drewsteignton	378	2	
Throwleigh	149	1	
Sourton	217	—	
Bondleigh	67	—	
Totals	1,743	6	Average, 0·34

States in 1880, was by no means the same as that of pneumonia; also Sturges stated that at Gibraltar different winds appeared responsible for the two diseases—the east, which is damp, seemed to promote the occurrence of bronchitis; the west, which there is dry, the occurrence of pneumonia. It would appear that whereas dry cold tends to cause pneumonia, damp cold rather tends to cause bronchitis. On the other hand, a warm, moist atmosphere has undoubted therapeutic value in the drier varieties of bronchitis. In how many disorders can we so confidently recommend a health resort as we advise Torquay or Falmouth in bronchial irritation?

Cancer.—Turning to other diseases. Of the climatology of cancer we may certainly say we know nothing of importance. Haviland's suggestion that the disease is chiefly prevalent in river valleys which are periodically flooded is one which, in Devonshire at all events, I cannot substantiate. But I admit my endeavours have been very limited. In tropical countries I think the evidence is strong that amongst natives living under usual conditions it is relatively rare.

Heart disease has a climatology well worth looking into. Haviland held that it was most prevalent in places not well flushed by wind. But very little has been done on the subject. Only a few years ago authoritative statements were made in reference to a district well known to me which were the direct reverse of the facts.

Nephritis.—Here again very little has been done, although more information seems at our disposal than in the case of heart disease.

Some other diseases.—For *asthma* we have a good deal of empiric knowledge, the chief fact being its capriciousness. *Gout and rheumatism, dyspepsia, anæmia, neurasthenia, neuralgia, and convalescence from acute diseases* have, apart from balneology, each a certain useful climatology of its own, but discordant statements are made in respect of them.

The importance of considerations such as the foregoing may be made still more obvious by also regarding them from the points of view of diagnosis, prognosis, prevention, and treatment.

IMPORTANCE IN DIAGNOSIS

The question whether a patient has resided in the tropics is a familiar one to all of us in dealing with a travelled person and an obscure complaint. Similarly we recognise the value of knowing the haunts of malaria and of hydatid disease. But how often do we think it helpful to consider whether a case comes to us from a neighbourhood where we could easily ascertain that tuberculosis or cancer is exceptionally rife? Yet this inquiry is scarcely less reasonable than the question whether the family history of the patient presents an unusual frequency of tuberculosis or cancer. The undue commonness of cancer or tuberculosis in a family should, most people will agree, make us doubly careful in our search for it in a suspicious case. Equally I would submit that the fact of residence in a district where one or other is exceptionally frequent should lead to unusual care in setting aside its diagnosis. There are districts in England where phthisis is six times more prevalent, and districts where cancer is almost three times more prevalent, than in others.

Again, in estimating the liability of the individual before us to cancer, certainly in making the difficult and essential early diagnosis, when no element of probability should be beneath our notice, has it ever occurred to us to wonder if the so-called cancer age is the same in all parts of the country?

Cancer Ages in North-East Cornwall

The following figures suggest that it is not. The north-east of Cornwall is a region of unusual longevity, and if senility of tissue is a more or less necessary condition for the commencement of carcinoma it might be reasonably expected that the cancer age, where longevity is relatively greater, might be more advanced than in the large centres of population, where, as I have shown, longevity is so remarkably less. My friend, Dr. W. F. Thompson, medical officer of health of Launceston, has furnished me with the returns on which the accompanying tables are based. (See Table IV.) In the first I have compared the distribution of all cases of cancer, in the successive decades from 35 onwards, in Launceston and Camelford registration districts, with the age

distribution in England and Wales generally. Clearly, in the Cornish districts the age of greatest frequency comes about a decade later than in England and Wales at large. The

TABLE IV

Cancer Ages in North-East Cornwall

PERCENTAGES OF CASES DYING AT VARIOUS AGE-PERIODS

All Organs

	England and Wales (1891–1900), 221,169 deaths at 35 and over.	Launceston and Camelford Registration Districts (1897–1907), 176 deaths.
Age 35–44	10	4
,, 45–54	22	12
,, 55–64	29	28
,, 65–74	26	29
,, 75 and over	11	25

Stomach

	Various London Hospitals (Fenwick 1902), 882 cases.	Same districts and period, 44 cases.
Age 30–40	14	—
,, 40–50	29	11
,, 50–60	33	13
,, 60–70	18	34
,, 70–80	1·5	31
,, 80 and over	—	11

Uterus

	Two Manchester Hospitals (Sinclair 1896), 131 cases.	Same districts and period, 19 cases.
Age under 30	2	—
,, 30–40	26	—
,, 40–50	42	16
,, 50–60	26	37
,, 60–70	3	31
,, 70 and over	0·7	16

Breast

	Middlesex Hospital (Sheild 1898), 831 cases.	Same districts and period, 21 cases.
Age 25–40	14	—
,, 40–50	32	19
,, 50–60	29	19
,, 60 and over	25	62

figures, however, are small for the Cornish districts, and I have therefore sought confirmation in a separate consideration of the ages in different organs. In their case I have compared the ages, not with the country at large, but with

those quoted by well-known authorities from great hospitals in crowded towns. In Launceston and Camelford districts it would appear that the ages of chief commonness of cancer of stomach, uterus, and breast are in each case almost twenty years later than those observed in certain great city hospitals. These differences are very remarkable, though such small figures can only be taken as suggestive. If their indications are true, the probability of cancer in a patient of 40 years of age in such districts as these two in north-east Cornwall is definitely less than in these large centres of population. May not such differences be found to be partly climatic?

IMPORTANCE IN PROGNOSIS

Turning next to prognosis, it is curious to contrast the stress laid on it by the ancients with our modern avoidance of it. Hippocrates attached as much importance to its correct estimate as our patients do now. We, on the other hand, think we show our wisdom by declining to prognose, and, as so generally is the case, atrophy tends to follow disuse. Amongst other conditions of which we may acquire knowledge is the difference in the expectation of life in some chronic diseases in different parts of this country. *Rheumatic fever*, for instance, is commoner in a certain midland town than it is near Exeter. Therefore the prognosis of a young valvular heart case should be better near Exeter than in that town. I have in mind a case of heart which got much worse in that place and greatly improved near Exeter, a case which led me to inquire as to the commonness of rheumatic heart disease in the neighbourhood I refer to. Again *bronchitis and emphysema* used to form, I remember, a large proportion of the out-patient cases at University College Hospital, London, when I was a house physician there. On the other hand, I found it rather uncommon at the Exeter Dispensary and in my wards at the Royal Devon and Exeter Hospital. The prognosis of emphysema should therefore be presumably better in Exeter than in London. Similarly, if the pulmonic circulation is less liable in Exeter to the accident of bronchitis, the prognosis of *mitral disease of the heart* should also be better in Exeter than in London. I believe it to be so, and to this point I shall presently return.

But the local differences are probably much wider than these few examples indicate. I was greatly struck, a few years ago, by a statement published by a justly celebrated physician as to the prognosis of aortic regurgitation. His experience was drawn from a densely populated area, and he had never seen a case of aortic regurgitation which survived the discovery of the lesion for more than fifteen years. Yet much longer survivals are common enough in Devonshire. For instance, one young woman, with a well-marked aortic regurgitant murmur, which I heard twenty years ago, is still going about almost as well as ever, although her heart is larger and the murmur louder and more widely audible. Had the statement I refer to come from a less reliable source I should probably have disregarded it. But, coming whence it did, it set me thinking. I knew that the longevity of our Devon country districts is remarkable, and it seemed to me worth inquiring what differences in general longevity existed between different parts of England and Wales. Accordingly, I calculated, for every registration district in England and Wales, and for the decade 1891-1900, the percentage of the total deaths, which were formed by those occurring at 75 and over, and found the most extraordinary disparities.[1] Whereas in many districts 25 per cent. of the deaths occurred at 75 and over, in many others only 7 per cent. and less occurred at those ages. In one Yorkshire rural district the percentage was actually 29·4, whilst in one great industrial centre it was as low as 2·2. I tried to discover how far a difference in infantile death-rate would explain the disparity, and found it only went a very little way. It seemed almost impossible to explain away the differences by the movement of younger lives to the great centres of population from the rural districts. Both of these factors helped undoubtedly to account for the disparities, but to no very great extent. There seems no doubt that a very marked difference exists, in expectation of life generally, between the great towns and the country districts. If so, surely this must affect the prognosis of almost all chronic disease, and as most of our efforts at prognosis, inadequate as they sometimes have been, emanate from our crowded centres, there clearly is need for extensive inquiry into the prognosis of these complaints in our rural areas, where I am sure the outlook is different.

Moreover, if density of population has this effect, is it not possible that by comparing rural populations with each other we may come to discover climatic factors also which tend to modify longevity? This seems to me an investigation which promises to repay the trouble it would entail.

IMPORTANCE IN PREVENTION

If it be true that a certain disease is specially rare in a certain place, and if it can be shown that this rarity is not merely fortuitous, may we not hold that a patient prone to that disease will, by residing in that place, have a specially good hope of avoiding the disease?

Such a consideration applies to tuberculosis, and one chief reason why I have devoted so much time to endeavouring to establish the value of shelter from rain-bearing wind in lessening the frequency of pulmonary tuberculosis is because I see, in places so sheltered, the most suitable place of residence for those in whom tubercle has become quiescent, or for those who belong to families whose proclivity to tuberculosis is pronounced. I feel sure that there are districts in England which cases of phthisis would be wise to avoid and where sanatoria ought not to be erected.

Similarly, I think that there are districts where old people with strong cancerous family history should not settle, and districts where those who have had repeated attacks of pneumonia run some risk in residing. One cannot be dogmatic yet on these two latter points, but would it not be well if one could?

IMPORTANCE IN TREATMENT

Once upon a time the medical faculty of this country laid much stress on climate in the cure of consumption. Now the fashion has changed. For (softly be it spoken) there is a fashion in therapeutics not so very far removed from a fashion in frocks! And there is a type of mind which accounts for much of this fashion. It may be described as the unidimensional mind, a type of intelligence which only discerns one cause for a single effect. Thus, do open-air methods of treatment hold out new hopes? Then climate and drugs are to be discarded! Is tuberculin found to be valuable?

Then sanatoria are to be decried! To the misapprehension induced by this sort of mind has climate, I believe, succumbed in the therapeutics of phthisis. What right have we at present to believe that the methods of open air, graduated exercise, and tuberculin administration cannot be aided by judiciously selected climates? It may be that they cannot. But it is wholly unjustifiable to assume it. In his Harveian oration, only two years ago, the late Dr. Theodore Williams, whose practical comparison of climates remains as a model for us all, stated that the results of the Swiss high-altitude sanatoria were twice as good as those obtained at ordinary levels. More recently, on the other hand, sanatorium results have been reported almost at sea-level as good, it is claimed, as those in the Alps. Here is a divergence of opinion surely badly in need of being cleared up.* Again, it has perhaps been forgotten that no European resort nowadays claims such success as Dr. Fuentes, quoted by Archibald Smith, assigned in 1858 to Jauja in the Peruvian Andes. 1858 is no doubt a very long while ago, and since then Koch's discovery of the bacillus of tubercle has drawn a barrier of demarcation across the history of phthisis investigation, so that all antecedent statements require confirmation. Yet it is worth recalling that, in the interesting and valuable series of cases of high-altitude treatment of phthisis published in 1869 by Sir Hermann Weber, in a paper read before the Royal Medical and Chirurgical Society, the most successful were those which were sent to the Andes. That high altitude has a value in other diseases, such as certain cases of asthma, of Graves's disease, and of malaria, is admitted: why not in phthisis?

If any one is desirous of testing anew the value of the Peruvian Andes, the present time would appear to be propitious. The terrible Isthmus of Panama has been almost shorn of its malaria and "Yellow Jack." Good steamers carry

* The comparison of results from sanatoria is a peculiarly difficult one. So much depends on the type of case admitted, the class, the duration of stay, and, even more, on the mode of arriving at the diagnosis and the particular bias in classifying results. If, as in one recent report, cases are discussed as phthisis in which bacilli could not be discovered, surely the door is open to errors of the gravest sort. If comparisons are made between different sanatoria, only cases should be taken into account in which bacilli have been demonstrated, and these should be grouped on some uniform plan according to stage and type.

the traveller from England to Callao in 28 or 30 days, and the Oroya Railway traverses in 48 hours huge passes which formerly had to be painfully crossed on mule back. Whether Spanish food and housing have progressed in the Andes, as they have in parts of modern Spain, I do not know. If so, not so very much has to be complained of. But it is unlikely, and those who go to Andean mountain towns will probably have to be prepared for roughing it in the way both of quarters and cuisine.

In short, taking into account all the foregoing, there can be no doubt of the immense importance of medical climatology, however we regard it, whether from the standpoint of diagnosis, prognosis, prevention, or treatment. We already possess valuable information in all its various branches; if I have barely mentioned medical geography and history, it is because in those the importance of our possessions is unquestionable. As I have said, it is when we come to the theory of the subject, the scaffolding on which we depend so largely for the further advancement of our building of knowledge, that we find our footing so seriously insecure.

THE PRESENT NEGLECT OF MEDICAL CLIMATOLOGY

But, if the importance of medical climatology is great, great also is the present general neglect of it. That more and more valuable information is continually becoming available only seems to interest the few; for the many, the references in the text-books are shrinking, the student hears less and less about the subject as time goes on, and the busy practitioner, so trained, naturally does not trouble himself very greatly in regard to it. As Sir William Whitla expresses it, in his chapter on phthisis in his recent work on the "Practice of Medicine": "The view is gradually gaining ground that there is no special curative element in any special climatic conditions" (p. 1353); and (p. 1297): "Climate on the whole must be said to play a minor rôle in its causation."

What is the consequence? The late Dr. Solly, of Colorado Springs, put it with such clearness in 1897 that I cannot do better than quote his words:—

If we consider [he wrote] how great a sacrifice of time,

money, inclination, and affection is involved when an invalid, under direction of a physician, leaves his home and journeys into another and perhaps a far country, we marvel at the small amount of thought and study that is bestowed by the majority of physicians upon the science of medical climatology; for without a fair knowledge and appreciation of this no rational selection of climate can be made.

The deficiency begins [he continues] with the medical schools, which should teach at least the broad principles of climatology and the outlines of climatic therapeutics. What would be thought to-day of the physician who diagnosed and prescribed for a disease of some organ of whose structure and physiology he was ignorant, or of the surgeon who proceeded to operate upon parts the anatomy of which he had not studied? Why, then, should a physician presume, as so many do, to prescribe a climate without having acquainted himself with the meteorological facts and climatic data, and with their meaning and significance?

It is sixteen years since these words were written. Yet they apply now just as much as they did then. There is no department of medicine in which so much ignorance prevails or in which such culpable carelessness is tolerated. If we accept the definition I have given of climatology, the seriousness of the existing point of view at once becomes manifest. Neglect on so large a scale must have more than trivial consequences, and it is not surprising to find that the consequences are common and disastrous. This is all the more regrettable at the present time, when the growth of the ancillary sciences, especially of geography and meteorology, the increasing number of stations at which weather observations are recorded, the publication of works of reference, and the multiplication of admirable maps, orographical, geological, and meteorological, are putting at our disposal invaluable means and methods of investigation.

SOME REMEDIES FOR THIS NEGLECT

For such a state of affairs a remedy will have to be found. In what direction shall we turn with most probability of discovering it? As in physical disease diagnosis must precede treatment, so here our first inquiry must be, "What are the reasons for this neglect?" I believe that

they will be found in climatology itself. Solly refers to one of the causes:—

On turning to the mass of literature available upon climatological subjects, we find it largely composed of empirical and biased accounts of various health resorts, and that these reports differ little in their statements of the advantages to be derived. Commonly each claims for its own resort the ability to cure all diseases, and the only invalids warned against coming are those in whom disease is far advanced. The facts given are few, and logical deductions from them are rare. In despair of making a choice from such sources the physician is apt to take the casual opinion of patients or of other laymen who have visited certain resorts and to select the climate accordingly. He cannot, however, form a correct judgment from such information unless he has previously grounded himself in the fundamental principles of climatology and studied the recorded facts. In this desert of rubbish there are, nevertheless, bright oases of truth and reason, such as are to be found in the writings of Weber, Hirsch, Jourdanet, Lombard, Vivenot, Rohden, Copland, Davidson, Denison, Yeo, the Williamsons (father and son), and others.

Here in the department of medical geography there is clearly room for reform. And there is every indication that workers are moving towards it. In recently dealing with one small section of Dr. Neville Wood's valuable volume on the "Health Resorts of the British Islands," I was much impressed by the sincere desire evinced throughout the health resorts of the south-west of England to present to the medical public a faithful picture of their merits and demerits. Too sanguine statements of my own, from limited central experience, were ruthlessly cut down from closer knowledge by my local correspondents. Rarely did it seem to me that even local enthusiasm had stepped ahead of certainty. The method pursued in that work of combining a central observer with local reporters seems to me one which may be widely extended with advantage. Moreover, a centrally placed writer dealing with very large numbers of patients spread over many health resorts, as was the case with the late Dr. Theodore Williams, can furnish invaluable dispassionate comparisons of results obtained in one place with those gained in another. Williams's careful observations upon selected

cases disposed of the claims of Pau and went far to establish the value of Davos.

Of such summaries we have far too few. It was Sir Hermann Weber who, by this sort of comparison, drew wide-spread attention in this country to high altitudes, and particularly to the Peruvian. Needless to say, the utmost care must be taken to contrast only cases which are actually comparable, and not to draw conclusions from numbers which are inadequate. Moreover, the summaries must, of course, be unbiased. As I have already indicated, our theories of climatology are far too immature to allow them to colour our judgment of the facts. For years to come we must be satisfied to patiently record observations, however unexpected, however inexplicable some of us may consider them to be.

But more than this is necessary. It is beginning to be suggested that climatology should be specially taught, that there should be special chairs of climatology in our medical schools. That must ultimately be so, and although the time seems scarcely ripe for a separate chair of climatology, a combined chair of what Dr. Fortescue Fox has well called "hydrology" and of climatology should undoubtedly be established somewhere in this country. Not only is the time ripe for it, but England has already fallen behind other countries for want of it. This is especially unfortunate, since the materials for climatic investigation in England are second to none in richness and accuracy. Such a chair would go far to stimulate much-needed investigation, and it is to be hoped that its establishment will not be long delayed.

But we must learn as well as lecture. And the question arises in what way? Shall I be pardoned if I insist upon a principle about which I have recently written? It seems to me to go deep towards the foundation of a sound science, not perhaps affording an absolute remedy for our uncertainties, but possessing merits which cannot be overlooked. I allude to what I have called "the principle of approximate isolation of influences." Hitherto it has only been imperfectly recognised, if indeed it can be said to have been definitely recognised at all. Yet without it I can see no escape from the theoretical chaos which confronts us. By such approximate isolation I mean not merely the happy-go-lucky elimina-

tion of this or that influence in the investigation of a third, but the systematic enumeration of all the known influences which seem to affect the field of inquiry besides the influence in question, and their successive elimination from the problem in one way or another, so far as that is possible. The process naturally is neither easy nor short.

Let us ask ourselves what progress would have been possible in bacteriology if investigators had continued to work with the mixed broth cultures of Pasteur? What precision of knowledge could we have attained as to the life-history of the majority of micro-organisms? Modern bacteriology may be said to date from Koch's discovery of isolation methods. Similarly (though unhappily no such absolute isolation is here possible), if climatology is to take its true place in medicine, some sort of isolation of influences will have to be attempted.

The older literature of the influence on phthisis prevalence of altitude or of soil is fairly comparable to the mixed broth culture of the micro-organisms. In neither was a serious systematic attempt made to eliminate other known influences. Müller's work on altitude and phthisis in Switzerland, which I shall discuss in detail in my next lecture, goes farthest in this direction, but not far enough. He eliminated the influence of occupation by considering separately agricultural, industrial, and "mixed" populations, and got rid of the effect on the figures of imported cases of the disease by deducting the percentage so imported in each locality. But although he gave interesting notes on soil and social conditions other than occupational, he made no attempt to eliminate their effect, nor do his notes suffice for us to do so.

Buchanan in his Reports to the Privy Council on the relations of phthisis to dampness of soil eliminated no other influence. Density of population, difference of occupation, and other social factors, all obviously liable to affect his figures, were allowed to confuse his problem; and his method of manipulating his figures by guesswork, to correct for imported cases and for the presence of institutions, cannot be too strongly condemned.

In the second lecture I propose to furnish illustrations—first, of the systematic application, and second, of the neglect, of this principle. For its systematic application I am sorry

I can only refer to my own work, and I shall do so very briefly, as it has already been sufficiently enlarged on elsewhere. The results of the neglect of the principle I shall illustrate by a revision, in the light of it, of the so-called "altitude theory of phthisis immunity," and show that, so reviewed, the existing evidence in favour of that theory absolutely crumbles to pieces.

LECTURE II

The Principle of Approximate Isolation of Influences

ILLUSTRATION I.—THE INFLUENCE OF RAIN-BEARING WIND ON THE PREVALENCE OF PHTHISIS

Dr. Parkes Weber and Gentlemen,—My first illustration of the value of the "principle of approximate isolation of influences" must be drawn from my own work. I shall deal with it very briefly as it has been so fully discussed elsewhere.[1] I cannot exaggerate the feeling of security one gains from it in climatic investigation. In addition to the factors of climate, which I have already enumerated, there are a number of other influences which have to be eliminated. These are set forth in the second half of Table I. They were dealt with as follows :—

Race has undoubtedly a very strong influence on phthisis, and to eliminate it only populations of the same race were compared with one another. With regard to *sex*, female death-rates for several reasons afford a better criterion than male, and only female death-rates were used when possible. *Occupation* has a marked effect, and therefore localities where special industries were almost universal were excluded from consideration. To eliminate *density of population* town and country were not compared with one another. To get rid of the effect of *preventive measures against the disease*, the figures referring to periods previous to the introduction of these were used when possible, where preventive measures had been adopted. *The progressive change in prevalence with lapse of time* was prevented from introducing error by the

comparison of only contemporary records. The other influences were shown to be so much less powerful than that of rainy wind that, where they could not be separately investigated, they might rightly be regarded as most unlikely to introduce error.

ILLUSTRATION II.—THE HIGH-ALTITUDE THEORY OF PHTHISIS IMMUNITY

To illustrate the consequences of the neglect of this principle I have taken the work hitherto done on the "high-altitude theory of phthisis immunity."

There is no more fascinating chapter in medicine than that which deals with altitude and phthisis. Its setting is superb. The most magnificent regions of the earth, some of the most famous, form the scenery. The names on its pages are amongst our most honoured. It ranges over the most diverse climates and raises the most fundamental questions of climatology.

Originating in the vast valleys of the Andes, where from time immemorial consumptives from the coast have been restored to health, and where the natives were believed to be practically immune, the theory that altitude was in some way antagonistic to the disease was first announced to Europe by Dr. Archibald Smith[2] in his writings from 1840 onwards. His statements were subsequently confirmed by Tschudi[3] and by Guilbert,[4] whilst evidence of similar rarity at almost equal altitudes was furnished by Jourdanet,[5] from the high plateau of Mexico. German observers took up the idea at home, and endeavoured to show, at much lower elevations, a diminution in the prevalence of phthisis with increasing height. Brockmann[6] and Fuchs[7] in the Hartz, Virchow[8] in the Spessart, Virchow and Brehmer[9] in the Silesian valleys, von Corval[10] in Baden, and Merbach[11] in Saxony, are all said by Hirsch[12] to have made this diminution probable. In Switzerland, dealing with altitudes more comparable to those of the Andes and over a much larger area, Lombard,[13] Müller,[14] and others published statistics of the greatest interest.

Sir Hermann Weber[15] was one of the first to test the value of both Alpine and Andean stations, and the remarkable success which he reported, especially from the Andes, drew

general attention in this country. The late Dr. Theodore Williams [16] furnished striking evidence of the value of the Swiss stations in the treatment of early cases, but was one of the first to throw doubt on the truth of the theory. This doubt has been increased by the discovery that in cities like Quito, formerly said to be almost immune, consumption is common, and the recent results of sanatorium treatment at low levels have (not quite logically) diminished the belief that altitude has anything to do with either the prevalence or the course of the disease. The general failure of the Himalayas as a health resort in consumption, even at heights of over 6,000 feet, contributes to the increasing doubt, and it might almost be said at the present time that the high altitude theory is moribund. But it is by no means dead, and as lately as 1906 the late Dr. Huggard, of Davos, in his Handbook of Climatic Treatment, quoted a table [17] published in 1895 by the sanitary department of the Grisons. The summary of this table (Table IX.) seems to show very clearly a decrease of phthisis incidence with increasing height. To it, and to the arguments adduced in the extensive literature which preceded it, no satisfactory answer has hitherto been given. It is such an answer that I am now endeavouring to provide. *I propose to show that no valid evidence exists that altitude*, per se, *has any influence upon the prevalence of phthisis*.

But it is necessary at the outset to lay down certain limitations. First, no one now claims that any altitude confers an absolute immunity from phthisis; that, therefore, needs no discussion. Secondly, the earlier statements as to the rarity of the disease in crowded cities at great heights have been shown to hold true no longer—if, indeed, they ever were correct. They will, therefore, not be now considered, except very briefly as follows: At Mexico, Jourdanet [18] never claimed more than a relative rarity as compared with the coast, and placed the death-rate at 2·1 per 1,000; and Le Roy de Méricourt [19] gave it at 4·7. In Bogota, according to Restrepo,[20] and at Quito, according to Jacobi,[21] phthisis enters largely into the mortality lists. This is remarkable, seeing that in 1878 Gayraud and Domec,[22] writing of Quito, said: "Our personal experience allows us to affirm that phthisis is so rare that we may say it does not exist there; at least, as a malady originating locally. . . . The fact is, then, indisputable for us

. . . one does not become phthisical at Quito" (Hirsch). Restrepo gives details which perhaps throw light on this remarkable statement. At Bogota about 50 per cent. of the cattle coming from the lower country are tubercular, and the diseased parts are eaten by the very poor. It is amongst these very poor that the disease is common, and the form of the disease is peculiar. The intestines are always affected, and, in the lungs, the apices are not oftener attacked than other parts. There is little tendency to the formation of cavities or of fibroid tissue, and the symptoms differ strikingly from those of phthisis as we know it. With a very chronic course, a usually subnormal temperature, no night sweats, very rarely cough, sputum, or hæmoptysis, the picture presented is one of intractable diarrhœa, digestive troubles, and emaciation. Such a disorder would scarcely have suggested pulmonary consumption to observers who in 1878 knew nothing of the tubercle bacillus. But their mistake must render us cautious in accepting the earlier views. Restrepo's account, however, by no means disproves a real rarity of ordinary phthisis from inhalation of the human form of the bacillus.

Lastly, a sharp distinction must be drawn here, as in all investigations of the climatic relations of tuberculosis, between an influence on prevalence and an influence on course. I am only here discussing the influence on prevalence. These separate influences have, I think, been too much intermingled in discussing the altitude theory—as the brief outline of its vicissitudes has indicated. It might perhaps be expected that places where phthisis is exceptionally rare would be generally beneficial to imported cases; yet this is by no means true. In tropical countries, away from the crowded towns, consumption, though rare, is usually rapid in its course; and in the Peruvian Sierra Archibald Smith has carefully indicated localities where, though phthisis was practically non-existent amongst the natives, the developed disease did badly. The converse proposition, however, that places where phthisis is exceptionally common might be expected to prove unfavourable to imported cases, seems to have more to be said for it. I know of no place where consumption is rife yet where imported cases do well. In dealing, therefore, with altitudes, such as the Himalayas, where it is particularly difficult to

obtain direct evidence regarding the prevalence of the disease, it may be held permissible, in absence of direct information (always remembering the uncertainty of such reasoning), to make use of authoritative statements as to an unfavourable effect upon its course. Otherwise I shall confine all I have to say strictly to the influence on prevalence.

I shall deal first with the Andes, not merely because the theory arose there, but because the climate is in several respects unique; secondly, with the Swiss Alps, where the most important work has been done on the subject; thirdly, with the German uplands and other European elevations; then with the Himalayas and other Indian altitudes; and finally, with the tablelands of South America, of South Africa, and Persia.

I must again point out that Koch's discovery of the tubercle bacillus in 1882 has made a landmark in the history. Before 1882 diagnosis was definitely more doubtful than it has since become, and instances will be noticed in which serious misstatements have consequently arisen—in fact, one such has probably been already mentioned, since it is unlikely that the frequency of pulmonary tuberculosis now recognised amongst the poor of Quito is of only recent development. Some of the statements date back to the first half of last century, and it might be held that such antiquated opinion should be altogether neglected. But, as it forms part of the existing argument, and as it may be justly urged that phthisis has so long been a clinically well-recognised disease, not usually mistakable at its actual termination, this can scarcely be done. In all cases, however, I shall qualify my information by adding its date.

The Andes

There can be no doubt that the Peruvian Andes, in the latitude of Lima, present a striking contrast to the adjacent coast in relation to phthisis prevalence. Dr. Campodonico says, in a valuable letter written to me in 1905: "In Lima the death-rate from tuberculosis is very high, as is seen from the enclosed statistics" (it was 7·7 per 1,000 in 1904); but "it is perfectly true that the inland plateaux of Peru are almost absolutely free from phthisis."

It must also be borne in mind (it is proper to allude to this here) that, correctly or not, the claims made for the valley of

Jauja as a sanatorium for phthisis considerably exceed any claims which have been advanced elsewhere. Whereas in Lima the disease runs a rapidly fatal course, at Jauja, at an elevation of about 10,000 feet, Dr. Fuentes[23] stated in 1858 that over 79 per cent. of the patients recovered, and of the recoveries quoted by Sir Hermann Weber[24] in the paper I have referred to, some of the most remarkable took place in these mountains. We have thus definitely in this part of Peru a remarkable contrast between adjacent lowland and highland in respect of the relation to phthisis. It remains to be decided upon what peculiarity this contrast depends.

In the first place, it must be observed that the climatic contrast is equally pronounced. Lima is only 565 feet above sea-level in a climate by no means usual in the tropics, sheltered by the Andes from the south-east trade-winds, very damp but almost rainless, and chilled by the great Antarctic current which, running northwards along the Pacific coast and carrying, from Southern Chili to some distance north of the equator, a vast body of cold water, cools the atmosphere of both sea and land and frequently covers both with a roof of cloud.

"For more than half the year," says Mr. Bryce,[25] "Lima has a peculiar climate. It is never cold enough to have a fire, but usually cold enough to make you wish for one. It never rains, but it is never dry; that is to say, it is not wet enough to make one hold up an umbrella, yet wet enough to soak one's clothes. September was as dark as a London November and as damp as an Edinburgh February, for the fog was of that penetrating and wetting kind which in the case of Scotland they call a 'haar.'" For the other part of the year there is tropical heat. When to this we add that this climate is very enervating, that the inhabitants are remarkable for their effeminacy and delicacy of constitution, the men especially, with their contracted chests, who find shaving and washing the face in cold water sufficient to cause catarrh (!)[26]; that the city is a large one containing over 100,000 inhabitants, of all sorts of races; that the death-rate from all causes in 1840 was about three times that of London or Manchester, and was over 35 per 1,000 in 1903,[27] it need cause no surprise that the tuberculosis rate is a high one.

On the other hand, the climates and conditions to which

Dr. Archibald Smith specially drew attention are entirely different. As it is necessary to be precise, I must quote his own statements as they stand.

> Certain states of the air of the atmosphere, depending on different degrees of altitude, appear to be either hostile or favourable, according to the particular locality in which the patient happens to reside. . . . Thus on the coast it is a common disease, but on the intermedial mountains and in the temperate valleys of the interior it is rare.[28]

He elsewhere carefully refers to the " deep warm glens of the interior " as the favourable localities.[29]

> Huarriaca is in climate very like Obrajillo, on the western slope of the Andes [elsewhere he says that Obrajillo is in a hollow locked in by hills], and in one of those recesses in the Andine glens and defiles very productive of maize. . . . Such indeed are the marked localities, blessed with a steady temperate climate and a dry air of about sixty degrees Fahrenheit in the shade as well as sunny cheerful sky throughout the greater part of the year. Such are the localities where phthisis proper, or tubercular disease of the lungs, is only known as an exotic. . . . The sky of the dry intermediary valley . . . is generally throughout the whole year remarkably pure, bright, and serene.[30]

Of Jauja he says : " With a sky always bright and sunny and an atmosphere pure and bracing which invites to outdoor exercise and enjoyment." [31] In confirmation of Smith's statements Campodonico writes of the territory of Junin where " Tarma, Jauja, and Huancayo are situated,"

> These towns, protected as they are by the lofty range of the Andes, which deflects the trade winds, can hardly be said to have any regular winds. The climate is very dry, although the rainfall reaches a high point in the months of December, January, and February, when sudden and frequent showers occur, the water dries away rapidly—iron tools are very rarely oxidised.[32]

He attributes the rarity of phthisis to several causes ; for instance, " dryness of the air, the effectual Andean screen sheltering from humid southern winds, sparseness of population, with a consequent less pollution of the air." It must

also be noticed that the towns are small and that the occupations of the people are pastoral and agricultural, "the harvest being home, the rural population rest from their agricultural labour for eight months in the year, which they give up to amusement and feasting."

Dr. Theodore Williams carefully described the valley of Jauja [33] :—

> The valley of Jauja is a plateau 44 miles long and 17 wide, separating the two ranges of Andes . . . entirely drained towards the east by the Mantaro. . . . The soil is alluvial with a calcareous substratum. The year is made up of two seasons—the dry season, which is the coldest, extending from March to August, in which last month frost occurs, and the rainy, called the winter, which is the hottest, extending from September to February. Thunderstorms occur in January and February, and wind is most felt in July and August—[i.e., one observes it in the dry season] . . . The climate does not admit of great extremes and the thermometer falls sometimes to 28° Fahr., seldom rising much above 57° Fahr. (in shade). The sun's rays are powerful and so great in their direct influence that in the full sunshine the temperature may be 122° Fahr. and in the shade 50° Fahr. The atmosphere is very clear, partly on account of rapid evaporation, and partly because of the rapid drainage by the river Mantaro. Iron and steel are stated never to rust, and such is the transparency of the atmosphere that stars are seen by day. The prevailing winds are south-west in the evening and the north-east in the morning, and occasionally they blow sufficiently to cause a tempest.

It should be observed that at the silver mines of Pasco over 14,000 feet above sea-level, "with a wet season like a Scotch winter and, though in the dry season it shines brightly and warmly at noon, yet in the shade the air is chillingly cold and the nights always frosty," although imported cases did not improve, Smith only once in a year's residence met with a case of hæmoptysis.

In a most interesting account of Bolivia kindly sent me six weeks ago by Dr. Ramsay Smith, British Consul at Orura (to which I trust to do fuller justice in a future paper), he emphasises the extreme rarity of any sort of tuberculosis amongst those born and bred in his district, which lies about 12,000 feet above sea-level.

It should be noted that no one has tried to show, so far as I am aware, any *increasing* rarity with increasing altitude in the Andes. The optimum height for treatment is stated to lie between 5,000 and 10,000 feet.

Now race cannot account for the difference. For instance, Campodonico tells me "that inlanders may easily contract tuberculosis when they leave the tableland of the Andes and come to the coast; in fact, on the coast of Peru the largest tribute to mortality from tuberculosis is paid by them." So also the chest enlargement, on which stress has elsewhere been laid, affords here no adequate explanation, since these inlanders exhibit it. Differences in occupation and in density of population may go far of themselves to account for the difference of prevalence. For in the sheltered tableland of Kashmir Dr. Arthur Neve tells me that whereas in the insanitary, overcrowded city of Srinagar phthisis "is not rare," "it is almost unknown" outside it. In Kashmir no great difference of altitude enters into the problem, yet the contrast between town and country is apparently the same.

When we add together differences in climate, which produce an enervated, delicate, and narrow-chested population in Lima, and a healthy broad-chested people in the Sierra; between a very damp and a very dry climate; between a sky overcast for half the year and the nearly continuous brilliancy of a tropical sun through a most diaphanous atmosphere; between conditions which are described by Archibald Smith as depressing to appetite and hindering to digestion, and conditions which he found to be exactly the reverse—differences, moreover, whose effects we have been afforded no means of separately estimating and eliminating; it is clear that we cannot assert that the lesser prevalence on the heights is in any direct way determined by mere altitude.

The Andean valleys, indeed, present an almost unique climate—well within the tropics, only about 12° from the equator, yet singularly equable and temperate, with a remarkably dry, still atmosphere, with the disinfecting presence of great intensity of light, yet without the excessive shade temperature which incubates bacilli; and when we add to these conditions sparseness of population and pastoral and agricultural occupations, with no overwork and with healthful outdoor life, we shall find little difficulty in explain-

ing even a unique rarity of phthisis within them without invoking altitude or its equivalent in diminished barometric pressure to account for it.

In short, the Andean valleys described by Archibald Smith furnish no valid evidence in favour of the theory he propounded. As regards the therapeutic effect of these altitudes, the mere reduction of temperature from that of the tropics for part of the year on the coast to that of temperate climates in the Sierra must be an agent of immense importance.

The Swiss Alps

The work done in Switzerland was the most important in Europe. The altitudes dealt with were great, the area extensive, the material carefully scrutinised, and the methods used more thorough than elsewhere. I shall therefore discuss it in some detail.

Dr. Lombard, of Geneva, in his charmingly lucid "Climats de Montagnes," stated that at the higher inhabited altitudes in the Alps phthisis was comparatively rare. "I have shown," he wrote in 1873, "that the rarity of phthisis on the heights is an indisputable fact," and later on, "One may take it that phthisis is almost unknown above 2,000 metres." But he insisted on a very interesting and important point which Hirsch has not noticed—viz., that at intermediate heights a belt of increased phthisis normally exists, a "*phthisis zone*,"[34] above and below which the disease is less prevalent, a zone placed, he thought, approximately between 1,300 or 1,600 feet and about 3,000 or 4,000 feet of altitude. It was also, he found, a zone of greater frequency of "scrofula." This belt roughly corresponded with another belt of increased humidity, greater rainfall, damper soil, more mist and cloud, and more frequent thunderstorms, which reached, he said, from about 1,600 or 2,000 feet above sea-level to about 3,000 or 5,000 feet. He also described a belt of forest and meadow in which herbaceous and arborescent plants took on more luxuriant growth, stretching from about 1,600 feet to about 6,000 feet.

Now, this point of a "phthisis zone," if correct, is of the greatest moment, as it at once casts doubt on all the work which has been done at levels which do not reach its higher limit. Thus Lombard goes on to say :—

But is this so [the lessening of phthisis prevalence] for all mountain regions? We do not think so, and we shall see that, if a belt exists where phthisis is nearly completely unknown, there are other regions where the disease acquires a degree of frequency much greater than that observed in the surrounding plains.

A large number of papers, he tells us, exist to show this. Dr. Locher-Balber found tubercular disease twice as common in the mountain districts of Canton Zürich as down by the lake. He makes the interesting statement that a Dr. Mansford published in 1818 a work intended to show that in England phthisis patients were more numerous in proportion as their dwellings were more elevated, a conclusion which my own observation bears out, when the localities examined are exposed to westerly winds. Lombard explains the apparent contradiction by pointing out that the localities quoted were within the belt of increased phthisis mortality. My observations would suggest that the increase of their phthisis death-rate was due to their elevation increasing their rainy wind exposure.

And here it will be well to glance at the climatic influences exerted by mountains and to try to get some rational notion of how mere altitude might act upon the prevalence of phthisis. The feature which presents the greatest regularity with increase of altitude is decrease of barometric pressure, and this has been supposed by some to be the factor which tends to produce a relative phthisis immunity. Roughly speaking, at 6,000 feet the air pressure is about 25 per cent. less than at sea-level. At that level the effect of the decrease in oxygen pressure becomes noticeable to the new-comer, and a condition which Jourdanet named anoxyhæmia develops. To compensate for this a rapid increase of hæmoglobin and red corpuscles occurs, so that Viault, who investigated it in Peru, found that in two weeks his red corpuscles increased from 5 to 7 millions per cubic millimetre and in another week to 8 millions. The amount of iron in the blood rose in the ratio of 4 to 7. Also the chest measurements increase, so that the natives of these high altitudes have larger chests than those who live below. Both of these compensatory changes have been given as explanations of the supposed immunity.

With increasing altitude the intensity of insolation also increases, so that at the summit of Mont Blanc the intensity of solar radiation is 26 per cent. greater than at the level of Paris, and a marked increase in the intensity of the ultra-violet rays exists at great altitudes and an increase in the chemical effect of sunlight. Nevertheless, the air temperature falls, and both annual and daily range of temperature considerably diminish, the climate therefore becoming cooler and more equable.

An intermediate belt does exist, such as Lombard described, of greater humidity, rainfall, and cloud. In the tropics this is at an altitude of between 1,300 and 1,600 metres. In higher latitudes it varies with the season, in winter being lower, in summer higher. The rainfall increases with the increasing altitude up to a certain point, at which it again decreases. It should be borne in mind that the central mountains of Germany and those of England are below the altitude above which the rainfall lessens. In the north-west Himalayas, Hill[35] found the zone of maximum rainfall during the monsoon was about 1,270 metres above sea-level, and if the rainfall on the plains be taken as 1, the amount in this maximum zone was 3·7, but at 3,000 metres only 0·2. Season considerably modifies the position of these zones.

That increased chest capacity does not prevent phthisis we have already learnt from Dr. Campodonico's statement, as well as from general experience of relapses on patients leaving higher levels. The increase in red corpuscles and hæmoglobin might conceivably tend to hinder the development of phthisis ; the increased solar radiation, and especially of the ultra-violet rays, would destroy bacilli exposed to them, and at great heights the dryness of the air should be prophylactic. On the other hand, the zone of increased rainfall and cloud would have the contrary effect. The proof, however, here, as always, must depend not on theoretical expectation, but on ascertained facts.

In 1863 a Commission was appointed by the Swiss Natural Science Society to investigate the distribution of phthisis in Switzerland, with a view to determining the influence of altitude. The five years 1865 to 1869 were selected as the period of observation. Dr. Müller, of Winterthur, acted as secretary. In his careful and elaborate report Müller points

out that the period of observation chosen was too short. It was, however, the utmost possible, and in many places—indeed, in some entire cantons—it was found unattainable, returns being only procurable for four, three, or even two years. Moreover, the figures, he says, were not free from omissions and errors, though he indicates those which he thinks definitely open to doubt. Great pains were clearly taken to make the best of the materials, and the statistics were drawn from a very wide area and great population. This report, therefore, is entitled to the most attentive consideration. We shall see that it does not prove that phthisis prevalence necessarily diminishes as altitude increases.

TABLE V

Death-rates from Phthisis at Successive Altitudes in Switzerland (Müller) per 1,000 *per annum*

Altitude in metres.	Altitude in feet.	Industrial districts.	Mixed districts.	Agricultural districts.
200– 499	656–1,639	2·7	1·85	1·4
500– 699	1,640–2,295	3·0	1·55	1·2
700– 899	2,296–2,951	1·35	1·7	0·7
900–1,099	2,952–3,608	1·5	1·9	0·7
1,100–1,299	3,609–4,264	2·3	2·3	0·7
1,300–1,499	4,265–4,920	—	1·4	0·6
Over 1,500	4,921–5,905	—	1·3	0·7

Müller eliminates the disturbing influence of occupation, which obviously greatly affected the death-rates, by grouping the localities as "industrial," "agricultural," and "mixed," and by considering each separately. Table V. gives the relation of phthisis to altitude in each of these groups. The industrial districts do not seem to prove any relationship, nor do the agricultural districts above the height of 700 metres (about 2,300 feet). But the "mixed" cantons might be held to suggest a relation (if we may assume that Lombard was right in his opinion about an intermediate belt of greater mortality and therefore neglect the heavier and increasing death-rates between 700 and 1,300 metres).

But Müller further provides another set of statistics (which Hirsch has overlooked) eliminating a source of error, which

in Switzerland, where so many of the inhabitants go to other countries to work and return home when ill, is particularly liable to mislead—viz., the inclusion of cases which originated elsewhere. Table VI. embodies these figures. Here again the industrial districts give no definite indication, and the agricultural above 700 metres show no signs of decrease, but the "mixed" districts suggest even more strongly than before a decrease with increasing altitude, except for a passing increase between 700 and 1,100 metres. It must, however, be remembered that of the three groups the most indefinite as regards occupation is the mixed, for the amount of industrial occupation, of course, varies from place to place.

TABLE VI

Müller's Table after Omission of Imported Cases

Altitude in feet.	Industrial districts.	Mixed districts.	Agricultural districts.
656–1,639	1·8	1·4	1·2
1,640–2,295	2·1	1·2	1·1
2,296–2,951	—	1·3	0·6
2,952–3,608	1·3	1·3	0·5
3,609–4,264	2·2	1·1	0·7
4,265–4,920	—	1·0	0·6
4,921–5,905	—	0·8	0·7

There is, however, another powerful influence which has to be taken into account, of which Müller was not aware—viz., the influence of prevalent rain-bearing winds. These are the north-west, west, and south-west, for the greater part of Switzerland, with perhaps the south-east for the lower valleys, which run down into Italy. Of the westerly winds the chief rainy wind appears, throughout Central Europe, to be the north-west.

To examine the effects of these winds I have constructed from Müller's work Tables VII. and VIII., excluding all towns of more than 10,000 inhabitants (in order to lessen error from density of population), all districts where a hospital was said to exist, all where the period of observation had been less than five years, and all where the number of

TABLE VII

Being Müller's Table XVI. modified as stated

X = Exposed to S.W., W., or N.W. Winds. S = Sheltered from all of them.

District.	Canton.	Population.	Phthisis of local origin. Deaths in 5 years.	Phthisis of local origin. Annual death-rate per 1,000.	Exposure or shelter to westerly winds.
Altitude 200–499 *metres* (656–1,639 ft.)					
INDUSTRIAL					
Mendrisio (town)	Tessin	2,200	26	2·3	X S.W.
Zug (town)	Zug	4,066	38	1·8	X W., N.W.
Diessenhofen (town)	Thurgau	1,595	12	1·5	X ,,
Lenzburg (town)	Aargau	2,297	15	1·3	?X W., S.W.
Coldrerio, Salorino	Tessin	1,018	3	0·5	?S
	Totals	11,176	94	Av. 1·6	
MIXED					
Lachen	Schwyz	1,532	18	2·3	X N.W.
Sargans, Mels	St. Gallen	3,997	39	1·9	X ,,
Cully (town)	Waadt	1,089	8	1·4	X S.W.
Anières, etc.	Genf	3,472	24	1·3	X ,,
Liestal, Seltisberg	Baselland	4,027	25	1·2	X N.W.
Lausen	,,	781	5	1·2	X ,, ?
Ormalingen, etc.	,,	1,199	6	1·0	S
Colombier, etc.	Neuenburg	2,355	12	1·0	?X S.W.
Gelterkinden	Baselland	2,198	10	0·9	S
Tenniken, etc.	,,	1,164	2	0·3	S
Sissach, etc.	,,	3,087	4	0·2	S ½ ?
	Totals	24,901	153	Av. 1·2	
AGRICULTURAL					
Unterhallau	Schaffhausen	2,370	30	2·5	?
Begnins, etc.	Waadt	1,977	18	1·8	X S.W.
Erlach-Lüscherz, etc.	Bern	2,684	23	1·7	X ,,
Maisprach, etc.	Baselland	1,213	9	1·4	S
Jussy	Genf	873	6	1·3	X S.W.
Wintersingen, etc.	Baselland	753	5	1·3	½S
Ins, etc.	Bern	2,835	19	1·3	X S.W.
Walchwyl	Zug	1,055	6	1·1	X N.W.
Basadingen	Thurgau	2,095	10	0·9	X W., N.W.
Satigny	Genf	3,546	17	0·9	X S.W.
Andelfingen	Zürich	5,851	19	0·6	?
Risch	Zug	960	2	0·4	S
Arisdorf, etc.	Baselland	1,097	2	0·3	S
	Totals	27,309	166	Av. 1·2	
Altitude 500–699 *metres* (1,640–2,295 ft.)					
INDUSTRIAL					
Unterseen	Bern	1,732	20	2·3	X W.
Bauma	Zürich	2,939	27	1·8	? X N.W.
	Totals	4,671	47	Av. 2·0	

TABLE VII.—*continued*

District.	Canton.	Population.	Phthisis of local origin. Deaths in 5 years.	Phthisis of local origin. Annual death-rate per 1,000.	Exposure or shelter to westerly winds.
		MIXED			
Meyringen. . .	Bern	4,739	46	1·9	? X W.
Diegten, etc. . .	Baselland	1,623	13	1·6	?
Laüfelfingen . .	,,	734	6	1·6	?
Neuheim . . .	Zug	700	5	1·4	X W., N.W.
Wenslingen . .	Baselland	634	4	1·2	X N.W.
Hutwyl (town) . .	Bern	3,254	21	1·2	X ,,
Rümlingen, etc. .	Baselland	1,387	6	0·8	½X
Zeglingen, etc. . .	,,	1,245	5	0·8	½X
	Totals	14,316	106	Av. 1·4	
	AGRICULTURAL				
Ringenburg . .	Bern	1,123	14	2·4	X S.W.
Grandvaux . .	Waadt	1,713	17	1·9	X S.W., W.
Bremgarten . .	Bern	2,125	15	1·4	X S.W.
St Saphorin, etc. .	Waadt	2,868	20	1·3	X S.W., W.
Leissigen, etc. . .	Bern	800	5	1·2	X N.W.
Kirchlindach . .	,,	809	5	1·2	X S.W.
Valle Capriasca. .	Tessin	2,967	14	0·9	S
Wohlen . . .	Bern	3,211	16	0·9	X S.W.
Gsteig . . .	,,	7,418	33	0·8	½X W.
Rapperswyl . .	,,	1,888	6	0·6	?
	Totals	24,922	145	Av. 1·1	
	Altitude 700–899 *metres* (2,296–2,951 *ft.*)				
	NO INDUSTRIAL				
		MIXED			
Menzingen . .	Zug	2,248	33	2·9	X N.W., W.
Couvet . . .	Neuenburg	2,102	17	1·7	?
Oberoegeri . .	Zug	1,905	6	0·6	S
Unteroegeri . .	,,	2,492	3	0·2	S
	Totals	8,747	59	Av. 1·3	
	AGRICULTURAL				
Arzier . . .	Waadt	358	4	2·2	X S.W.
Gimel, etc. . .	,,	1,823	12	1·3	?
Pfäffers . . .	St. Gallen	600	4	1·3	X N.W.
Trois Torrens . .	Wallis	1,313	6	0·9	S
Dürrenroth . .	Bern	1,408	6	0·8	S
Bassins, etc. . .	Waadt	912	3	0·6	?
	Totals	6,414	35	Av. 1·09	

TABLE VII—*continued*

District.	Canton.	Population.	Phthisis of local origin. Deaths in 5 years.	Phthisis of local origin. Annual death-rate per 1,000.	Exposure or shelter to westerly winds.
Altitude 900–1,099 *metres* (2,952–3,608 *ft.*)					
INDUSTRIAL					
Sternenburg . .	Zürich	1,038	11	2·1	XS.W.,W.,N.W.
Les Bayards . .	Neuenburg	958	9	1·8	X S.W.
	Totals	1,996	20	Av. 2·0	
NO MIXED AGRICULTURAL					
St. Georges, etc. .	Waadt	720	6	1·6	X S.W.
Vättis . . .	St. Gallen	350	1	0·5	S
Boltigen . . .	Bern	2,010	6	0·5	S "(? if complete)"
Frutigen, etc. . .	,,	5,224	15	0·5	S "(? if complete)"
Lenk	,,	2,288	5	0·4	S "(? if complete)"
Weisstannen . .	St. Gallen	471	1	0·4	S
Ayent. Vex. . .	Wallis	1,962	2	0·2	S
	Totals	13,025	36	Av. 0·5	
Altitude 1,100–1,299 *metres* (3,609–4,264 ft.)					
INDUSTRIAL					
St. Croix . . .	Waadt	4,574	50	2·1	?
NO MIXED AGRICULTURAL					
Revereulaz, etc. .	Wallis	273	7	5·1	? X N.W.
Agettes and Herémence	,,	1,368	1	0·1	S
Gsteig, etc. . .	Bern	1,415	2	0·2	S "(? if complete)"
	Totals	3,056	10	Av. 0·6	
Altitude 1,300–1,499 *metres* (4,265–4,920 ft.)					
NO INDUSTRIAL					
NO MIXED AGRICULTURAL					
Adelboden . .	Bern	1,544	5	0·6	S "(? if complete)"
Nax, St. Martin .	Wallis	2,734	3	0·2	¾ S
	Totals	4,278	8	Av. 0·3	
Altitude 1,500 *metres and upwards* (4,921–5,905 ft.)					
NO INDUSTRIAL					
NO MIXED AGRICULTURAL					
Champéry . . .	Wallis	548	2	0·7	S

cases really of local origin could not be determined. Here again the agricultural group over 700 metres shows no signs of a decrease in phthisis with increase of height, whilst both the "mixed" and industrial groups indicate an *increase* of phthisis, which in the latter is actually progressive over

TABLE VIII

Summary of Averages in Table VII

Height over sea-level in metres.	Occupations of localities.	Phthisis of local origin. Average death-rates per 1,000.		
		Industrial.	Mixed.	Agricultural.
200–499 (656–1,639 ft.)	Industrial	1·6		
	Mixed		1·2	
	Agricultural			1·2
500–699 (1,640–2,295 ft.)	Industrial	2·0		
	Mixed		1·4	
	Agricultural			1·1
700–899 (2,296–2,951 ft.)	Industrial	—		
	Mixed		1·3	
	Agricultural			1·09
900–1,099 (2,952–3,608 ft.)	Industrial	2·0		
	Mixed		—	
	Agricultural			0·5
1,100–1,299 (3,609–4,264 ft.)	Industrial	2·18		
	Mixed		—	
	Agricultural			0·6
1,300–1,499 (4,265–4,920 ft.)	Industrial	—		
	Mixed		—	
	Agricultural			0·3
1,500 and over (4,921–5,905 ft.)	Industrial	—		
	Mixed		—	
	Agricultural			0·7

500 metres. On examining the individual places as regards their exposure and shelter from westerly winds we see at once an easy explanation of a greater death-rate at lower levels where it occurs; below 700 metres the proportion of places exposed is considerably greater than that above. It becomes, therefore, clear that the apparent influence of altitude may be readily explained as an indirect effect of

wind exposure or shelter. The industrial districts happen to be almost all exposed, and increasing height merely carries them into regions of greater wind and rain; the "mixed" districts vary in death-rate apparently from the same cause; whilst the uniform lowness of death-rate in the agricultural localities of over 700 metres altitude seems to depend on their almost uniform shelter. Below 700 metres a considerable proportion of them are exposed, which accounts for their higher death-rates at the lower levels. It seems, in fact, as if, with increasing altitude, the increasing bleakness of the exposures had forced the inhabitants to build their villages in shelter, and the effect of this shelter in lowering phthisis death-rate had come to simulate a diminution in the prevalence of the disease directly due to altitude.

These tables conclusively dispose, I think, of any reasonable claim that in Switzerland during the five years selected an influence of altitude on the prevalence of phthisis, apart from increased or decreased exposure to rain-bearing wind, could be discovered. We have, however, in Müller's report still further evidence in the same direction, below the upper limit which Lombard assigned to his belt of increased prevalence. I lay particular stress on it because of its antagonism to more northern statistics presently to be quoted. The canton of Zürich was one of the most satisfactory in the series, because its returns were for five years throughout and appeared to the reporter exceptionally trustworthy.

Table XIX. gives the 13 highest districts, the 10 lowest, and the 15 districts with the least mortality from phthisis. It will be seen from these figures that in this canton, where elevation almost always means increased north-westerly exposure, increasing altitude is associated, not with lower, but with very definitely higher mortality from phthisis. The populations given lend no colour to an idea that density of population has a determining influence. Occupation, however, evidently has an effect, and, in fairness to the upholders of the altitude theory, one must protect them by precautions which all of them do not themselves adopt. Yet even when only agricultural districts are compared with each other it is seen that the lower localities still have the lower death-rates.

But we can deduce more from Müller's figures than a mere negation. It is plain that, in shelter amongst agricultural

populations, increase of altitude has no evident influence on phthisis prevalence; but what about populations exposed to rain-bearing winds? Of these we have here no certain examples above the limit which Lombard sets to his humid zone. Up to that limit, however, the phthisis prevalence appears to actually increase as we ascend, and we may reasonably ascribe this increase to the increased incidence of rain-bearing winds, since in shelter the same humidity at the same height may reasonably be assumed to exist, although it created no increase in the phthisis death-rates.

We may, in fact, state our conclusions so far thus: 1. In shelter from rain-bearing winds there is no evidence of any influence of altitude on phthisis prevalence. 2. In exposure to rain-bearing winds the prevalence of phthisis appears to increase with increasing altitude, within the limits of Lombard's zone of increased humidity and rainfall.

All the foregoing, however, is based on figures compiled before Koch's discovery in 1882. We now turn to the more modern and presumably more exact statistics published in 1895 by the Sanitary Department of the Grisons. They were held by the department to strongly support the idea that increasing altitude decreases the prevalence of tuberculosis. Three-quarters of the cases were pulmonary, and the figures may be reasonably dealt with as furnishing similar arguments for phthisis as for tuberculosis generally. For I have shown elsewhere that other forms of tuberculosis are affected by rainy-wind-exposure in much the same way as phthisis is. They express morbidities, not mortalities, and are therefore considerably larger.

The Grisons offers an exceptionally favourable field for investigating the question, as Müller had pointed out, since it provides such wide differences in inhabited altitude. Unfortunately, Müller had found it impossible to obtain satisfactory information from it. It also affords exceptionally marked contrasts of wind exposure and shelter. The west wind must be much broken and dried by its passage over the western Alps; the south-west seems only to gain free access to the Upper Engadine. The south-east may have some effect as a rainy wind on the highest villages of the valleys which run down into Italy. North-westerly winds probably affect the canton most. They are especially pre-

valent in summer, the time of the chief rainfall. The table published by the Sanitary Department (Table IX.) was, however, arranged in unequal divisions of altitude, and it was first necessary in examining it to arrange it in equal divisions. I did so in 200-metre divisions. (Table X.) So arranged, it by no means made clear a definite effect of

TABLE IX

Issued by the Sanitary Department of the Grisons (1895)

Number of communes.	Metres above sea.	Population.	Tubercular morbidity per 1,000.
15	285– 599	20,369	12·48
40	600– 999	20,935	9·74
64	1,000–1,499	25,346	7·18
19	1,500–1,880	10,291	5·64

altitude, and at each successive height pronounced exceptions were found to occur, which suggested some more potent influence in operation. It seemed possible that this influence was that of rain-bearing wind.

To ascertain whether rain-bearing winds had any influence on the figures given, a table was constructed showing the tuberculosis morbidity in places exposed to various winds,

TABLE X

The same Returns rearranged at Uniform Intervals of 200 *Metres*

	Morbidity per 1,000.
Places up to 600 metres high	12·08
„ from 601– 800 metres high	8·8
„ „ 801–1,000 „ „	12·5
„ „ 1,001–1,200 „ „	7·1
„ „ 1,201–1,400 „ „	7·5
„ „ 1,401–1,600 „ „	4·2
„ „ 1,601–1,880 „ „	8·6

and it at once became obvious that a higher rate accompanied exposure to any westerly winds. (Table XI.) Another table was drawn up of localities with morbidities under 5 per 1,000 and over 10 per 1,000.[36] The localities with lower rates were then seen, with few exceptions, to be sheltered from all westerly winds, whereas those with the higher rates were, with two exceptions, exposed to one or

other of them. The winds causing increased frequency of tuberculosis were generally north-westerly. So another table was drawn up comparing at each altitude the morbidities in the populations sheltered from north-westerly winds with those exposed to them. The result was very remarkable. (Table XII.) At every level the exposed populations suffered far more (twice to seven times as much) from tuberculosis than the sheltered. And one other important fact also became obvious—viz., that as altitude increased a greater proportion of the people tended to live in places sheltered from these winds, as if the exposures became too bleak for habitation. In neither exposed nor sheltered places was there evidence that altitude lessened the morbidity; on the

TABLE XI

Tuberculosis in the Grisons. Summary as regards Shelter and Exposure

Shelter and exposure.	Population.	Tuberculosis morbidity per 1,000.
Sheltered from all	18,734	5·3
Exposed only to W.N.W., N.W., or N.N.W. .	9,256	13·2
" " N. or N.E.	6,043	6·9
" " E.N.E., E., or S.E. . . .	6,173	5·8
" " W.	280	14·2
" " S.W. or W.S.W.	118	19·7

It should be observed that the populations exposed to W., S.W., and W.S.W., are very much smaller than the others.

contrary, in exposure the effect of altitude was not to lessen, but to increase it.

The incidence of westerly winds, therefore, not altitude, appeared to chiefly determine the distribution of the morbidity. To make quite sure, however, a table was made out showing the morbidity at successive heights in places sheltered from all westerly winds and from the south-east. (Table XIII.) From this table the conclusion seems inevitable that altitude of itself has little influence, if any, and only acts indirectly, in exposed places, by increasing the exposure. In fact, from these tuberculosis morbidities in the Grisons we arrive at precisely the same conclusions as from Müller's phthisis mortalities, of 30 years earlier, dealing with other cantons.

It should be noted that we have in these later statistics no means afforded us of eliminating errors due to imported cases, or to differences of occupations as we had in Müller's report. In my study of the district, the shelters and

TABLE XII

The N.W., N.N.W., and W.N.W. Winds. Effect of Exposure to, and Shelter from, them at Various Heights (Summary)

Altitude in metres.	Altitude in feet.	Fully exposed to N.W.		Fully sheltered from N.W.	
		Population.	Morbidity per 1,000.	Population.	Morbidity per 1,000.
Up to 600	1,968	14,039	14·4	4,874	5·3
601– 800	—	1,937	12·4	4,004	5·2
801–1,000	—	199	25·1	2,369	6·3
1,001–1,200	—	260	19·2	7,212	5·6
1,201–1,400	—	2,092	15·3	5,237	2·4
1,401–1,600	—	270	18·5	8,273	3·8
1,601–1,880	5,250–6,160	0	—	4,966	8·6

It should be observed that the exposed populations at 801–1,000, at 1,001–1,200, and at 1,401–1,600 metres are very small.

exposures were deduced with great care from the contoured Swiss Government survey maps, kindly lent me by the late Dr. Huggard.

As to Dr. Lombard's humid belt, it is interesting to see in Table XII. between 800 and 1,200 metres a definite increase

TABLE XIII

Sheltered from all Westerly Winds and from Sirocco (Summary)

	Morbidity	Population.
Up to 600 metres . . .	3·9 per 1,000 . . .	2,898
601– 800 ,, . . .	4·7 ,, . . .	3,173
801–1,000 ,, . . .	4·1 ,, . . .	971
1,001–1,200 ,, . . .	2·8 ,, . . .	4,254
1,201–1,400 ,, . . .	2·3 ,, . . .	5,059
1,401–1,600 ,, . . .	4·9 ,, . . .	3,693
1,601–1,880 ,, . . .	6·7 ,, . . .	3,538

in the morbidities both in shelter and exposure, especially in exposure, although the populations in exposure are too small for us to dare to draw any positive conclusions.

From these Swiss investigations, older and newer alike, therefore, I think we are entitled to affirm—

1. That altitude of itself has no evident effect on the mortality from phthisis, such as has been supposed to exist —in other words, that increasing altitude does not here of itself appreciably decrease phthisis prevalence.

2. That altitude has, however, in exposure to rain-bearing winds just the reverse effect, the prevalence increasing with the altitude, this being presumably due to increasing exposure to these winds.

3. That there is some support for Lombard's view that an intermediate zone of increased phthisis prevalence exists, roughly corresponding to the zone of maximum humidity and rainfall, at least in exposure to rain-bearing winds.

The Mountains of Germany

Taking, next, the work done on the German mountains, there are some general points which have to be remembered. In the first place all the localities dealt with are much lower than the highest inhabited Alpine, the higher ones coming, in fact, within Lombard's belt of increased phthisis prevalence. In the Hartz the heights dealt with are less than 2,000 feet above sea-level, in Saxony the highest are a little over 2,000, and in Baden not much over 3,000 feet; also they are all below the level at which rainfall ceases to increase with altitude, and probably also suffer more from wind in exposed situations at higher than at lower levels. The claim, therefore, that phthisis prevalence becomes less as elevation increases is evidently not the same thing as in the very high altitudes we have been discussing. Moreover, the shelter afforded in the recesses of these hills is increased by the forests with which they are so often clothed. Again, all the work on German heights was done before Koch's discovery in 1882, and consequently when diagnosis was less certain than afterwards. Brockmann's conclusions, in fact, rest on erroneous diagnosis, nor was such care taken in any of the papers to avoid error as characterised Müller's inquiries; soil and shelter here, as there, were omitted from consideration; and in addition it will be seen that no such satisfactory means were adopted to prevent confusion from such sources as differences of occupation, density of population, defective notification, and imported cases. The earliest

work was Brockmann's [6] on the Hartz in 1843. He alleged that pulmonary tuberculosis was less common on the plateau of the upper Hartz than below. In support of this he only quoted two considerably different levels, Clausthal, including Zellerfeld, at a height of about 2,000 feet, and Lerbach, a mere village lower down, in a narrow valley running due south-west. He definitely based his statements as to rarity on Clausthal. Now Clausthal is a mining town, with silver, lead, and copper mines, and he admitted that a form of consumption, which in his opinion was not tubercular, was very common there. The other form was evidently, from his description, miner's phthisis. Statistics of phthisis in a mining community, from which miner's phthisis is excluded,

TABLE XIV

Von Corval's Table for Baden, 1869–1872, *including all Tuberculous Deaths and Deaths from "Chronic Pneumonia"*

Altitude in feet.	Number of towns or villages.	Population. Average of 4 years.	Death-rate per 1,000.
330–1,000	750	933,773	3·36
1,000–1,500	337	224,210	2·75
1,500–2,000	160	81,066	2·60
2,000–2,500	190	104,287	2·75
2,500–3,000	97	59,155	2·33
Over 3,000	47	20,367	2·17

cannot be regarded as convincing, and his paper must be dismissed as valueless.

Von Corval's work [10] in Baden dealt with four years, 1869 to 1872; he allowed that his material was defective; all cases were not medically certified (he made no estimate of the proportion), and he found it necessary to include all cases certified as chronic pneumonia. (Table XIV.) Six groups of places were compared in ascending order of altitude, but, as the names of the places were not given, it is impossible to examine them further. He claimed to show that in higher altitude alone is to be sought one of the most important factors in hindering the development of consumption. Except for a partial elimination of density of population by tables from which towns of over 10,000, 5,000 and

3,000 inhabitants were successively excluded, no attempt was made to get rid of any conflicting influence. To do him fuller justice than he has done himself, or than Hirsch and Schlochow [37] have done him, I have calculated from his figures Table XV., which eliminates density of population down to a certain point, *i.e.* as far as he gives the means of doing.

Upon his work certain comments seem justifiable. It is true, as von Corval claims, that the last column in Table XV. suggests a certain tendency in the phthisis mortality to diminish as altitude increases, and this is not negatived by the other columns. But the figures show equally clearly an influence of size of town, and inasmuch as it is evident from his tables that the places over 3,000 feet have the largest

TABLE XV

Calculated from Von Corval's Figures

Groups.	Height in feet.	Phthisis death-rate per 1,000 living in towns of populations of Over 10,000.	5,000–10,000.	3,000–5,000.	Under 3,000.
I.	330–1,000	4·5	3·4	3·6	3·1
II.	1,000–1,500	—	2·9	3·5	2·7
III.	1,500–2,000	—	—	4·9	2·5
IV.	2,000–2,500	—	—	3·2	2·7
V.	2,500–3,000	—	—	3·0	2·3
VI.	over 3,000	—	—	—	2·1

percentage of small villages, decreased density of population may alone account for the lowest figure. Again, it was stated that by far the greatest number of inhabitants are occupied in agriculture and wine-growing, etc.—open-air occupations—but that a certain proportion are employed in manufactures, not only in the largest towns, but even in the narrowest valleys of the Schwartzwald. No attempt, however, was made to separate these, so that we are free to surmise that probably as altitude increases open-air employments become relatively more common. Further, in the highest villages it is likely that the percentage not medically certified increased, and that the apparent lessening of phthisis death-rate may be due to this. These three considerations alone would invalidate any conclusion founded on his tables. But we have another reason for rejecting them as proof of an influence of altitude. Hirsch supplies

a table showing the mean annual phthisis death-rate per 1,000 for the different circles of Baden only a few years later than von Corval's work—namely, 1874 to 1881.[38] (Table XVI.) Here we observe a still steeper decline in values, and if we examine an orographical map of Baden we shall see that these areas stand very much in their order of exposure to westerly and especially to north-westerly winds. Taking

TABLE XVI

Baden Average Annual Phthisis Death-rates per 1,000 *Inhabitants in the Various "Circles,"* 1874–1881 (Hirsch)

Mannheim	3·87	Constance	2·65
Karlsruhe	3·41	Lörrach	2·54
Baden	3·28	Mosbach	2·37
Freiburg	3·05	Villigen	2·36
Heidelberg	3·04	Waldshut	2·24
Offenburg	2·89		

into consideration, therefore, the effect of these four factors alone, which have not been eliminated in von Corval's work, his figures, I submit, lose all significance.

Merbach's table for Saxony[11] (Table XVII.), if we exclude the places under 200 metres high, only proves, if indeed it can be held to prove anything, that altitude has no effect whatever on phthisis prevalence. But he gives the names

TABLE XVII

Merbach's Table for Saxony, 1873–1875, *dealing with Towns of over* 5,000 *Inhabitants only and Deaths from Phthisis between the Ages of* 16 *and* 60 *years*

Elevation in metres	Phthisis death-rate per 1,000.
100–200	4·9
200–300	3·3
300–400	3·2
400–500	3·5
550–650	3·2

of the towns, their populations, altitudes, and phthisis death-rates. So that it is possible to examine them more fully and see if, in reality, any evidence of an influence of mere altitude exists. The highest town was only 2,066 feet above sea-level. Only towns were dealt with, but no distinction was drawn on the score of density of population or prevailing industry. The number of cases not medically certified was considerable, in some actually so many as 40 to 60 per cent.

of the total, but the percentage is given for each town. A survey of the map of Saxony will quickly show that the higher death-rates occur chiefly in the more open country, the lower amongst the hill valleys of the south-west. In Table XVIII. I have put a column of arrows to show the direction of the rivers on which the towns stand as a rough means of gauging their exposure. It is interesting to observe that the towns on rivers which flow towards the north-west, and are therefore exposed at least to winds from that quarter, have an average phthisis death-rate 50 per cent. higher than the towns which, standing on rivers flowing

TABLE XVIII

Saxon Towns according to direction of the Rivers on which they stand

Annual Phthisis Death-rate per 1,000 *at Ages* 14 *to* 60

	Averages.		
↗	3·2	3·1, 3·7, 2·1, 2·7, 3·8, 3·6, 2·5, 2·6, 2·4, 2·7, 4·5, 3·4, 4·2, 3·8, 4·1	
↑	3·6	3·7, 3·9, 3·7, 3·1, 4·4, 3·6, 3·0, 3·6, 3·3, 3·5	
↖	4·7	4·2, 3·2, 3·9, 4·3, 3·3, 5·3, 6·1, 4·6, 7·4, 4·5, 5·6, 4·9, 4·2	
←	3·6	3·6	much westward shelter.
↙	3·6	3·8, 3·4	

Or only considering Towns where at least 80 *per cent. of Cases were Medically Certified*

	Averages.	
↗	3·2	3·7, 2·1, 2·7, 3·8, 3·6, 2·5, 2·6, 4·3, 4·1
↖	4·7 nearly*	4·2, 4·9, 5·6, 4·5, 7 4, 4·6, 5·3, 3·3, 4·3, 3·2, 4·2

* *I.e.* nearly 50 per cent. more.

north-east, are more or less sheltered from all westerly winds, since these latter lie almost entirely amongst the hills. The variations in his figures, therefore, are presumably due in part to wind. With this, and other influences uneliminated, all significance of his work disappears.

Lübben[39] in 1880 dealt with the distribution of cases of tuberculosis in Thuringia (using morbidities, not mortalities) and only dealing with individual practices, in towns here and there, his tuberculosis rates being expressed in percentages of all sorts of cases of illness. Such material is obviously most unsatisfactory. No attempt was made to eliminate other influences, and the separate town morbidities were not stated.

All that his figures show, if indeed they can be admitted to show anything, is a certain rarity of tuberculosis in the Thuringenwald. Certainly no claim for altitude can be made from them.

Virchow's statement[8] that in the Spessart phthisis is

TABLE XIX

Canton Zürich (the city of Zürich excluded) (Müller)

Population.		Altitude.	Phthisis death-rate.	Metres high.
		Highest Parishes		
1,038	I	Sternenberg	1·2	900
2,228	I	Fischenthal	3·4	781
2,990	I	Bäretsweil	2·9	700–800
1,096	I	Hirtzel	2·5	700
4,713	I	Wald	2·0	650–870
1,726	I	Hittnau	2·0	640–770
1,435	I	Schönenberg	1·9	700
2,662	I	Hinweil	1·5	540–780
659	A	Hutten	1·5	740
690	A	Zumikon	1·5	700
2,203	?	Turbenthal	1·4	556–812
2,382	A	Egg	1·3	551–800
672	A	Aeugst	1·2	712
		Lowest Parishes—under 400 *metres* (1,312 *feet*)		
731	A	Weiach	1·9	389
733	?	Schlieren	1·6	395
2,288	A	Rorbas	1·3	396
1,390	A	Flaach	1·3	374
988	A	Rheinau	1·2	394
1,555	?	Dietikon	0·9	392
1,503	A	Eglisau	0·8	340
1,486	A	Glattfelden	0·8	369
2,822	A	Andelfingen	0·4	395
502	A	Dorlikon	0·4	390

Altitudes in Metres of Parishes with Phthisis Death-rates under 0·7 *per* 1,000

A 390	Dorlikon	0·4	per cent.	A 446	Regensdorf	0·5	per cent.
A 395	Andelfingen	0·4	,,	A 446	Stadel	0·6	,,
A 413	Marthalen	0·6	,,	A 532	Buch	0·3	,,
A 415	Laufen	0·5	,,	? 560	Uitikon	0·6	,,
A 422	Rümlang	0·5	,,	? 600	Riffelweil	0·4	,,
A 428	Dorf	0·5	,,	A 617	Regensberg	0·6	,,
A 434	Wyl	0·3	,,	? 630	Kyburg	0·5	,,
A 439	Dällikon	0·3	,,				

I means Industrial. A means Agricultural.

uncommon is only what one would expect from a sparsely inhabited densely forested hill country, and is explained by himself solely on the grounds of occupation and open air. Virchow himself made no suggestion that altitude had anything to do with the low death-rate, although Hirsch quotes his statement in support of this theory. Brehmer[9] found

phthisis non-existent in Görbersdorf at the height of about 1,700 feet; but Görbersdorf lies in an exceptionally sheltered valley on the east of the Riesengebirge, amongst their foothills.

With these observations in Germany should be compared Table XIX., Müller's figures for the canton of Zürich (already alluded to) at much the same heights, but where every death certificate had been medically signed, and where, for every parish separately, the necessary particulars of height, population, occupation, and number of cases originating locally had been carefully given. The result, as we have seen, was the exact reverse of the result in almost neighbouring Baden and the rest of the German districts examined.

Fuchs's comparison [7] of the great town of Hamburg with the sheltered little mountain town of Brotterode need not detain us, nor Küchenmeister's [40] now untenable generalisation. The German mountains, in short, afford no valid evidence whatever of an antagonism between altitude and phthisis.

Other European Heights

In England I have carefully examined the registration districts to discover whether difference in altitude has any effect on the disease—although our altitudes, needless to say, in no way compare with those which we have been discussing. The only fact I can trace is the same that I have traced abroad—namely, an increasing liability to phthisis where altitude increases exposure; and it is curious to note that in 1818, nearly a century ago, as already mentioned, an increase of phthisis with increase of altitude in England was recorded by Dr. Mansford, whose paper, unfortunately, I am unable to trace.

In the Pyrenees, Eaux-Bonnes, Eaux-Chaudes, Cauterets,[41] and other places have been mentioned by Sir Hermann Weber as freer from consumption than other localities in the plains below, but these towns are wonderfully free from wind, and have been specially described as sheltered by Dr. Burney Yeo,[42] who writes of Eaux-Bonnes: "There is exceedingly little wind, and I was assured by an excellent authority that the air is often so still that one may pass days without seeing a leaf stir on the trees." In the Alpes Mari-

times, Briançon, the highest town in Europe, has been quoted [43] as singularly free from consumption, but it is shut in and thus greatly sheltered by mountains.

The Indian Hill Stations

In the Himalayas the high altitude theory met with its first obviously serious reverse. It is true that Hirsch [44] has stated that immunity from phthisis came out decidedly on the northern and southern slopes of the Himalayas, at the elevated points of the Western Ghats, on the Nilgherri Hills, and on Mount Aboo, but he relied upon very old statements, some going back to 1823, which do not tally with more recent information. Some excuse for this lies in the wonderful difficulty of obtaining reliable knowledge of the frequency of phthisis in these regions. But the following statements seem sufficiently definite to quote.

Davidson states [45] that between 1867 and 1876, among the Goorkha regiments stationed at Dehra (2,232 feet), Dhurmsala (4,500 to 6,600 feet), Abbottahad (4,120 feet), Almora and Bakloh (both at considerable elevations), all on the south-westerly slopes of the Himalayas, the proportions of deaths from phthisis to the total mortality was as high as 20·3 per cent., whilst the proportion among the native troops stationed in the Gangetic province below was only 10·6 per cent. It should, however, be here observed that racial proclivity to phthisis appears to differ considerably in India, and the Goorkhas seem to be particularly liable to the disease. Davidson states that the highest elevations of the Western Ghats and of the Himalayas are not free from consumption, though it is there comparatively rare; but in Coorg, at an elevation nowhere under 3,000 feet, it is said to be very common.

Dr. Alexander Crombie,[46] reporting at the Congress of Tuberculosis at Berlin in 1899, on the prevalence of consumption in India, quotes Webb as stating "amongst the natives inhabiting the lower range of the Himalaya Mountains I have seen scrofulous swellings and ulcers of the neck common." The figures for the ten years ending 1896 showed that amongst native troops the higher rate of admissions for phthisis was in the hill regions. The three places where

phthisis appears to be rare—namely, Kashmir (in which it undoubtedly is so, as I learn from Dr. Neve), the valley of Nepal and Manipur [47]—are all in exceptionally sheltered situations. Kashmir is comparatively windless, and phthisis is almost unknown outside its capital, Srinagar, but in it it is by no means rare.

It should be remembered that the hill stations of India have in the rainy season an extremely heavy rainfall. In the absence of direct information regarding prevalence, it may be held permissible to mention, as bearing indirectly on the point, comparatively recent experience of the effect of Indian mountain resorts on the course of the disease. Their unsuitability has scarcely received the attention which the great experience of those who have insisted on it should have ensured.

Sir Joseph Fayrer [48] referred to them as follows: Simla (6,953 feet) " should be avoided by the phthisical." Ranikhet (6,086 feet) is not of much real service. Darjeeling (6,912 feet), more useful than the foregoing, enjoys considerable immunity from wind and storms. Pachmari (3,564 feet) is ineligible as a resort for phthisis. Mount Aboo (3,945 feet), phthisis is not benefited there. Mahableshwar (from 4,500 feet to 4,700 feet), after the mists set in in May, is prejudicial to phthisis. The Nilgherries, with their average elevation of station of about 6,500 feet, are not advantageous in phthisis; and Newera Eliya, Ceylon (6,150 feet), " has an evil reputation for cases of phthisis." At Dalhousie (6,800 feet), in 1897, Surgeon-General Keogh informed me that six admissions for phthisis in the early stages were returned to the plains because the climate was too severe for them. Here, therefore, we have very high altitudes which are detrimental to phthisis patients and in some of which the disease appears to be common. These, however, are situations open to wind and with a heavy rainfall.

The Rockies, South Africa, and Persia

Next, taking the Rocky Mountains, there is no doubt of the rarity of consumption in Colorado, New Mexico, and Arizona. From a study of Solly's " Medical Climatology " and Davidson's " Geographical Pathology " there can be no doubt of the rarity of phthisis in the eastern foot-hills of the Rockies and in their

valleys and tablelands, in spite of some prevalence of wind; but then the climate is very dry. The rainfall in places is as low as 9 inches annually. It does not seem, in fact, that, as regards the prevalence of phthisis, these districts differ much from lower countries which are similarly dry, like the Darling Downs of Australia or Upper Egypt. Similar remarks apply to the high tablelands of South Africa and Persia. In none of these situations has any attempt been made, so far as I know, to prove *increasing* rarity of phthisis with increasing altitude. The statements regarding Abyssinia are conflicting.

Taking all this considerable mass of information into account, and it is all that is at our disposal, it seems to me impossible to arrive at any other conclusion than that no evidence of any value exists in favour of the high altitude theory of phthisis immunity. Whether a fuller investigation on the lines of the principle which I have suggested will furnish any such evidence remains to be seen. To set the matter finally at rest it should be undertaken.

I trust that I have given sufficient illustration of the principle on which I have ventured to lay such stress—sufficient proof of its extreme importance. In closing my survey of the subject I would repeat my belief that the place of climatology in medicine should be, and is destined some day to be, a very great one, and, as a means of placing it there, I would once more urge the adoption of this principle.

THE MEDICINE OF THE FUTURE

Thus far, however, I have dealt only with medicine as at present understood, but in the progress of civilisation will there not also be an expansion of its scope? Shall we rest content with the advance only from what one may call "reparative" medicine to preventive medicine? Will not the tendency be to proceed to what may some day be described as "constructive medicine"—that is to say, to the actual use of medical science in building up a more perfect organism than man at present is? With this in view we come back to the ideas mooted by Hippocrates, and it would be unfitting for any one dealing in these days broadly with the subject of climatology to seem to fall behind the sandal-prints of the great Asiatic Greek. More than 2,000 years ago he pointed

out the advantage of living in a city which faced the morning sun, and though the greatest apparent exception to the rule he laid down was even then rising on its Seven Hills his view has received remarkable confirmation since. Capital cities have curiously often stood upon an east coast, not merely in States with which he was acquainted, but in what were then the distant Western Isles and unimagined lands beyond the Pillars of Hercules.

Kindred questions, too, perhaps unknown to him, have since suggested themselves. Why, for instance, does empire usually establish itself most securely westwards? Why, in the Lampadephoria of the nations, has the torch of culture been passed almost continually towards the Pole? To such questions we have no answer. Yet may they not indicate profound climatological truths which we would do wisely in trying to understand?

CONCLUSION

Gentlemen, I have done, and I am under no misapprehension in respect of my shortcomings. I have not even offered you a completed sketch. The outlook in some directions has seemed to me so wide that I have not ventured to delineate it. Only this I will say in conclusion to those who, upon the same road, are about to pass beyond me. Bearing always in mind the infinite care and patience which alone can lead to certainty, have that faith in your findings that needs no explanations, and lay aside expectation, which is the veil that hides the obvious; so shall you come into a new realm of intellect in which humanity has more than it knows to hope for.

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